ASPECTS OF ECOLOGY OF TIGER (*Panthera tigris*) IN THE CORBETT TIGER RESERVE, (UTTARANCHAL)

SUMMARY

THESIS

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Summary

Introduction

Tiger *Panthera tigris*, once distributed from Turkey to the sea of Okhotsik, is now survives only in isolated scattered population from India to Vietnam and in Sumatra, China and the Russian Far East. People from all over the world paid great concern to decline of tiger population and considerable efforts and reource has gone into tiger conservation. The Indian Government launched the tiger as the flagship species and considered it as the indicator of health and prosperity of Indian forests and on 1st April 1973 launched the "Project Tiger" for the conservation of the tiger and the biodiversity associated with it. Protected areas designated as tiger reserves under this scheme, have played an important role in saving the tiger from extinction. But despite all the efforts, population of tiger is continuing to decrease under the adverse effect of fragmentation, degradation, destruction and loss of habitat, poaching of tiger and its prey, tiger-human conflict and slackening protection effort. Most of the tiger reserves in India face the problem of human-tiger conflict which has arisen due to lack of compatibility between conservation interests of protected areas and needs and aspirations of local people living in and around the tiger reserves.

In fact significant reduction in human-tiger conflict, effective curbs on the poaching of tigers, better management policies, raising conservation awareness in local populations and provision of alternative of fodder and fuel to villagers dependent on tiger habitats can only ensure the long term conservation of the tiger. To achieve these goals it is crucial to have a thorough understanding of aspects of tiger ecology and the socio-economic profile of the people living in and around tiger habitats. The main aim of this study was to investigate the aspects of ecology of tiger in the Corbett Tiger Reserve. The study provides baseline information on the status of tiger and its major prey species, tiger-human conflict, feeding ecology of tiger, habitat conditions and people depence on buffer and resulting conflicts and peoples attitudes to alternatives and conservation, which is central to tailor effective management strategies for conservation of tiger.

Objectives of the Study

In order to investigate ecology of tiger in the buffer zone of the Corbett Tiger Reserve (CTR), I focused on the following objectives:

1. To study the habitat conditions and abundance of prey species of tigers in buffer zone of the Corbett Tiger Reserve.
2. To study the abundance and seasonal habitat use of tigers in buffer zone of the Corbett Tiger Reserve.
3. To study the feeding ecology of tigers in buffer zone of the Corbett Tiger Reserve.
4. To study the socio-economic conditions and level of tiger-human conflict in and around buffer zone of the Corbett Tiger Reserve.
5. To suggest strategies for mitigation of tiger-human conflict and long term conservation of tiger in the Corbett tiger Reserve.

Study area

The study was conducted in the Corbett Tiger Reserve (CTR), located in the civil districts of Nainital, Pauri Garhwal and Almora of Uttarakhand state of India. The Corbett Tiger Reserve, within its boundary, incoporates areas of Corbett National and Sonanadi Wildlife Sanctuary. Terrain of study area is hilly and consisting of a number of ridges and valley. The geological formation of study area is divided into recent and Siwalik series. The altitude ranges from 350 m 1210 m. Climate is tropical with three distinct season i.e. summer, monsoon and winter. The avearge temprature varies from 13 C^0 in January to 31 C^0 in May.Vegetation is quite heterogenous. Major portion of the area covered by sal *Shorea robusta* along with its several associates. According to the forest classification of Champion and Seth (1968), eight forest types are found in the CTR.

Methods

Camera trapping

Advanced technique of camera trapping based on principles of capture-recapture was employed to determine density of tiger in buffer zone of the CTR. Two trailmaster (USA) camera units were used for the photo trapping of tiger. After the pilot survey of the study area, 24 points were selected for the placement of camera trap unit.

Monitoring of livestock and human depredation

To study tiger-human coflict, carnivore attacks on livestock and humans reported by the villagers and forest department were inspected. GPS (Global positioning system) coordinates were recorded to determine spatial distribution of problem.

Monitoring of tiger kill

The buffer zone of the CTR and its sorroundings were searched to locate tiger kills. Wild and livestock kills of tiger were monitored to determine the feeding habits of tiger.

Scat Analysis

Scat analysis is indirect, non-invasive and unbiased technique to determine the diet composition of tiger and other mammalian carnivores. Scats were collected from in and around the buffer zone of the CTR. To determine the seasonal and annual variation in the diet of tiger, scats were seggregated season and yearwise.

Standardization of tiger scats was done to know minimum number of hair required to determine diet composition of tiger in the study area. Sample size estimation was carried out to determine minimum number of scats that required to be analyzed for reliable representation of tiger diet.

Line Transect Sampling

Standard line transect methodology appropriate to terrestial heribores was used to determine density of tiger major prey species. During the first phase of the study, 21 transects were randomly marked. During the second phase of the study, only 8 transect, located in the intesive study area were monitored. Transect length varied from 1.6 km to 3.5 km, depending upon the terrain in which they located.

Pellet Count

To determine relative abundace of different prey species in different forest blocks, indirect method of pellet cound was used. Pellet of differnt presy species were identified and recorded in 10 m radius circular random plots established in each forest block.

Habitat sampling

Quantification of the various habitat parameters and disturbance factors was done by laying sample plots, both on permanent transects, as well as, in different forest blocks of the buffer zone of the CTR. Whild tree layer was quantified in 10 m radius circular plot, shrubs were quantified in 3 m radius circular plot within 10 m radius plot. The seedling and sapling were counted in 1 m radius circular plot whereas ground layer was quantified in four 0.50X0.50 m quadrates at each sampling points. Data on disturbance factors were collected on an ordinal scale of 0 to 4.

To determine habita use by tiger, direct and indirect evidences of tiger were collected in different habitats found in the study area.

Socio-economic survey

Data on various socio-economic parameters and people's dependence on the forest were collected through both primary and secondary sources. Secondary data on the villages and *Gujjar deras* in the buffer zone were collected from the Forest Department, National Information Centres (NIC's) and *Gram sabhas* (village councils). A reconnaissance survey was carried out in all of the 123 villages and 17 *Gujjar deras* in buffer zone of the Corbett Tiger Reserve. A questionnaire was used to collect basic village level information about socio-economic profile of village and problems, dependence on the forest for livestock grazing, fuel wood and non-timber forest products (NTFP) and the forest blocks used. Nature of human-wildlife conflict and people's attitudes to alternatives to forest resources was also assessed using questionnaires.

The reconnaissance survey was followed by a more detailed survey in the sample villages and *deras*. For selecting sample villages, the buffer zone was divided into four zones. A total of 13 villages and 3 *deras* were selected for intensive sampling, on the basis of human and livestock populations as well as their spatial location *vis-a-vis* the buffer zone. Questionnaires were used to collect detailed information on socio-economic and demographic profile of communities in the sample villages and *deras* as well as, people's attitudes towards resource use, alternatives for reducing dependence on resources of the buffer zone, and conservation of CTR and wildlife.

Results

Abundance of tiger

The total sampling efforts were amounted 240 trap-nights and spread over a period of 5 months. Twenty four tiger captures recorded in survey helped to identify 20 individual tigers in survey area. The estimated population size *N* (SE [*N*]) derived using model M_h (Jackknife) was 44(10.69). The effective sampled area *A* (*W*) was 321.54 km^2. Therefore, the estimated tiger density D (SE [*D*]) for sampled area of the buffer zone of the CTR is 13.68 (3.32) per 100 km^2.

Tiger-human conflict

Human depredation

Tigers killed 3 humans while injured 16 humans during the study period. During the study period, 3 tigers were eliminated from in and around the buffer zone of the CTR in response to human depredation by tiger.

Livestock depredation

Most of the livestock depredation affected forest blocks were in the southeast of the buffer zone. All the blocks in the north, east and the west of the buffer zone either had no cattle depredation or low-level of cattle depredation.

Tigers killed 241, 245, 306, 293, and 333 cattle while injured 80, 55, 109, 136, and 126 cattle in 2002, 2003, 2004, 2005, and 2006 respectively. The livestock attacked by tigers during 5 years period (2002-06) were from 166 villages. Tigers attacked 1924 animals with an average rate of 12 animals/ village. Frequency of tiger's attack on livestock was highest (n=209) in monsoon.

From 2002 to 2006, tigers were responsible for estimated economic loss of Rs. 11,666,750 to people sharing range with tiger in and around the buffer zone of the CTR. Over period of 5 year, maximum loss was recorded in 2006 (Rs. 27, 39,500) while minimun in 2002 (Rs. 19, 47,750).

Food habits

Monitoring of kill

A total of 441 kills of tiger were monitored, out that 413 were of livestock while 28 were of wild prey species. Tiger mostly used techinique of strangulation for the killing of prey animal and mostly start feeding from the hind (rump) portion of victim.Tiger drags the carcass into dense shrub cover to conserve its kills and to avoid disturbances. Among the domesticated prey, cow was the most common prey species while in case of wild prey, chital was the most common prey species.

Scat analysis

Sample size estimation for minimum number of hair/scat

The number of hair to be examined per scat to detect 95% of the prey species were 18 hairs from each scat whereas all the prey species can be detected by examining 29 hairs from each scat.

Sample size estimation for minimum number of scat

Major prey species of tiger were detected by analysing 70 scats sample. Variation in percent prequency of occurrence of principal prey species achieved asymptote at 70 scats.

Percent occurrence of different prey species

A total of 15 prey species were recorded in the diet of tiger in the buffer zone of the CTR. Information of diet composition derived by analyzing 413 scats collected from study area indicated that wild prey comprised 84.2% while livestock comprised 14.8% of tiger diet. Unidentified prey remains contributed 1% of their diet. Chital was most important food of tiger in terms of number but in case of biomass, sambar was the most important prey species. Sambar contibuted 36.31% followed by chital (25.92%), cow (12.66%), buffalo (10.67%), nilgai (6.78%), wild pig (3.6%) to the biomass consumed. Muntjac, porcupine, hare, langur, rhesus monkey, jackal, civet and unidentified prey contributed less than 2% to the biomass consumed by tiger.

Sambar, nilgai and wild pig were found to be utilized more than their availability by tigers in the study area whereas chital and langur were found to be utilized less than their availability, when both group and individual density was used to calculate expected proportion of scats. But muntjac was found to be eaten in according to its availability when individual density was used to calculate expected proportion of scats but utilized less than its availability when group density was used to calculate expected proportion of scats.The overall diet diversity (H') of the tiger was 2.32 in the buffer zone of CTR.

Quantification prey base

A total of 567 km distance was walked during line transect monitoring during the study period. Density of all major prey species was 58±4.11 individuals/km^2. Chital (32.55±3.22) has the highest density followed by langur (26.03±5.25), sambar (4.4±0.57), muntjac (2.35±0.33), wild pig (2.3±0.49) and nilgai (0.73±0.32). Chital (36.5 pellet group/ha) has highest density of pellet groups while nilgai (3.5 pellet group/ha) has lowest pellet group density in the study area.

A total of 3137 kg/km^2 prey biomass was contibuted by major prey species. Muntjac (1.5%) contibuted minimum portion of prey biomass availability whereas chital (58.9%) contributed major portion of prey biomass followed by sambar (29.7%), langur (4.1%), nilgai (2.9%) and wild pig (2.7%).

Habitat condition

Sal *Shorea robusta* was found to be most dominated tree species and covered major portion of study area along with its various tree species associaties. The next most dominant tree species was *Mallotus phillippinensis*. Highest tree density (423.31/ha) was recorded on Transect-1 located in sal and mixed habitat in North Jaspur block whereas lowest tree density (151.85/ha) was recorded on Transect-2 located in mixed and plantation habitat in Dhela block. Transect-5 in mixed habitat type had highest tree diversity (1.1) and eveness (0.8) values while Transect-1 in sal and mixed habitat type had lowest tree richness (2.4) value. Transect-6 in mixed, sal and riverine habutat type had the lowest tree diversity (0.5) and evenness (0.4) values.

While highest shrub density (2297.63/ha) was recorded on Trasect-11 passing through plantations and mixed habitat type in Nalkatta forest block, the lowest shrub density was recorded on Transect-2 passing through plantations and mixed habitat type in Dhela forest block. Among forest block, highest shrub density (2773.47/ha) was recorded in Kalushaheed and lowest (377.85/ha) in Kalagarh forest block.

The sapling density (3022.5/ha) was highest on transect-11 in mixed and plantations while sapling density (34089.3/ha) was highest on Transect-3 passing through sal, mixed and plantations habitat type. While Transect-2 in mixed and plantations habitat type had highest herb density (75.6/m^2), lowest density (4.3/m^2) was recorded on Transect-5 in mixed habitat type.

Transect-2 in Dhela forest block showed highest evidence of grazing (1.91), dung piles (0.96) and weed proliferation (2.64) while Transect-1 in North Jaspur forest block had highest cutting pressure and Transect-4 in Sanwalde Bhavar forest block had highest lopping pressure.

Habitat use

Overall, 624 direct and indirect sightings of tiger were recorded during study period. While maximum evidences were recorded in mixed vegatation, minimum number of evidence were recoded in grassland habitat type. Data derived by comparasion of observed and expected frequency of evidences in different habitat types, indicated that tigers showed strong preference for mixed habitat type. While grassland, plantations, riverbed, sal and scrub were avoided, riverine and sal mixed habitat types were utilized in accordance to their availability.

Socio-economic profile of villages

A toatl of 140 human settements (Village and *Gujjar dera*) were surveyed during the study period. There were no villages inside the core zone of CTR except a *Gujjar dera* located in Goujada forest block of CTR. While 21 villages and 15 *deras* were located within the buffer zone, 29 villages and 2 *deras* were located adjacent (within 1km) to the boundary of the CTR. The remaining 73 settlements were located within a distance of 1-7 km of the CTR boundary.

Human population was a heterogenous group of 15 communities and a total of 77803 people and 58534 heads of livestock were dependent on the resources of CTR. Crop depredation by wild animals, threat to livestock and human life were identified as three major wildlife related problems amd more than 80% of the villages and *deras* were affected by these problems.

Agriculture, cattle rearing, business, labour activities and servive were identified as major occupation of people. While 12 of the 15 communities practiced agriculture as the major occupation, remaining 3 communities practiced it as a secondary occupation. Cattle rearing and labour activities were the other two major occupation practiced by three communities each.

While in Zones I, II, III more than 80% of the communities depended on CTR for fodder and fuelwood, dependence for timber and NTFPs was marginal. However Zone IV, less than 50% of the communities were dependent on fodder while 75% depended for fuelwood and here also dependence for timber and NTFPs was marginal. Majority of the communities were depended on the buffer for their fuelwood requirement and the major factors for dependence were-people can not afford alternatives, improper supply of LPG and wood was freely available. Fuel, fodder, tomber, water, NTFPs, cash earnings, cattle grazing, religious and recreation value were major benefits derived or perceived from the forest of buffer zone.

Majority of the respodents had negative attitudes towards restrictions on fuelwood from buffer and more than 50% were willing to steal wood from forest while 17% willing to agitate rather than go without it. Same in case of restriction on fodder and livestock grazing, majority of the people had negative attitudes and more than 50% were willing to steal fodder while 19% were willing to agitate rather go without it. While all the people felt the need for providing protection to the forest, majority of them felt that conservation of plants and animals was beneficial to them.

Conclusion

Carnivores are declinging globally under the combined pressure of degradation, fragmentation, destruction and loss of habitat, poaching, disease and persecution. Remaining tiger habitats in Indian sub-continent are like the islands surrounded by the land dominated by human populations and their future depend on the goodwill and support of people living around tiger habitats. This overlap with humans results in severe conflict between humans and tiger. Support of local people is crucial to achive conservation goals in human dominated landscapes. Thus to conserve tigers in India, conservation policies must incoporate strategies including protectionism, conservation education, public relations, community participation and revenue sharing. Community participation, however, requires strong partnership, shared goals for both wildlife and human communities and shared responsibility. People should be incoporate in management of protected areas.

The main conclusion or findings of the reaserch are

- Data on spatial distribution of tiger indicated that blocks located in southern and south eastern part of the buffer zone, had supported major portion of tiger population present in the buffer zone.

- Estimate of tiger density indicates that the buffer zone had high density of tiger. Buffer zone act as sink for tiger population in core zone of the CTR and act as source population for adjoining forest divisions therefore, play significant role in conservation of tiger.

- Tigers responsible for human attacks were not man eaters and occasional attack on humans was the result of sudden close encounter of humans with tiger and in response to self security or protecting their cubs.

- Livestock depredation by tiger was the major cause of human-tiger conflict in the study area. Livestock depredation by tiger in and around the buffer zone of the CTR was found to be highest in monsoon.

- High intensity of livestock depredation in Sanwalde, Bhavar, Dhela buffer and N. Jaspur forest blocks was because of the intensive pressure of livestock grazing in these forest blocks, which leads to decline in natural prey and grazing of livestock during the nights by *gujjars*, which makes the livestock more vulnerable to carnivore attacks.

- Compensation programmes increase tolerance of wildlife and promote more positive attitudes and support for conservation among local people. Compensation schemes should be friendlier and more acceptable to local people and there should be timely revision of rate of compensation.

- Data on diet analysis indicated that chital and sambar were the principal prey species of tiger and contributed major portion of tiger diet.

- Livestock also contributed significant portion (14.8%) of tiger diet in the study area.

- The disturbance factors such as livestock grazing and collection of fuelwood and fodder have negative effect on the quality of habitat.

- Data on habitat selection indicates that tigers were exercising some choice in selection of different habitats. Tigers were found to be preferring mixed vegetation and avoided grassland, plantation, riverbed and pure Sal habitats.

- With more than 90% of the villages dependent for their livelihood needs on forest of CTR, fuelwood was major resource being extracted.

- Large size of livestock holding had a high degree of dependence on the buffer zone of the CTR and consequently this dependence had a negative effect on the status of the forest.

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CERTIFICATE

This is to certify that the thesis entitled **"Aspects of Ecology of Tiger (*Panthera tigris*) in the Corbett Tiger Reserve, (Uttaranchal)"** submitted for the award of Doctor of Philosophy in Wildlife Science of the Aligarh Muslim University, Aligarh is the original work of Mr. Sharad Kumar.

This work has been done by the candidate under my supervision.

Jamal A. Khan

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1.1General

India, because of its location and diversity in environmental conditions, is well known for the bio-diversity it supports. However, bio-diversity of India is under the threat of increasing pressure of ever increasing human and livestock population and development activities. With the rapid growth of human and livestock population, forest are under escalating anthropogenic pressure resulting in their degradation especially in Asia, Africa and south China (Ericholm 1975, Upreti 1987, Pearce et al. 1990). Competing land uses and conversion of natural habitats for agriculture and infrastructure, industrial and commercial activities place increasing pressure on the India's forest, grassland, wetland, coastal and marine ecosystems. Human activities such as hunting, cattle grazing, cutting of trees for timber and fuelwood, collection of non-timber forest products and uncontrolled forest fires put further pressure on natural ecosystems and their native species (Mackinnon et al. 1999).

Large-scale changes in land use pattern and practices have adversely affected the distribution and abundance of wild animals especially the large and medium sized species. Under the pressure of various factors, habitat and distributional range of all wild species shrink and face the danger of extinction. The pressure of modernization along with unprecedented growth of human population and commercial exploitation has been a prime cause of decline of wildlife in India (Kushwaha et al. 2000). Due to various pressures many species got extinct and many are on the verge of extinction.

Increasing impact of human activities, on natural ecosystems has necessitated preservation and conservation of wilderness to maintain diversity of flora and fauna in their natural habitats. So for the conservation of bio-diversity, Indian Government notified various protected areas which act as milestones in the conservation of bio-diversity of India. The conservation of biological diversity got a boost after the formulation of Wildlife (Protection) Act, 1972. Although, protected areas are crucial for the conservation of bio-diversity, yet it has been observed that increasing human and cattle population have placed a significant pressure on the protected areas. When a protected area is created, it denied access of the local people to these areas. Local communities, living in and around protected areas, depend on them for livelihood, fuelwood and fodder for their cattle. They utilized the same resources as being used by the wildlife. Therefore, they compete with wild animals and give rise to man-animal conflict. The main threats to the Indian wildlife are habitat destruction, poaching, alteration of environment and growing conflict between wild animals and growing interests of human beings.

Most of the protected areas have substantial human population along their boundaries, whose agricultural, livestock farming and resource collecting activities bring villagers into competition and conflict with wild animals. The problem of man-animal conflict is as old as human civilization. Conflict between human being and the predators had existed since food animals were domesticated around 9,000 years ago (Nowell & Jackson 1996). Carnivore often killed the domesticated animal. Because of low human population and availability of large tracts of wilderness, magnitude of problem was negligible in the past. But, the problem became immense as the human population increased. As human population increases and the demand for resources grows, the frequency and intensity of conflict between the man and animal increased (Newmark et al. 1993). Wildlife habitats were exploited and destroyed at an alarming rate. Due to this, habitat and food for the wild animals decreased and in search of food, they move towards the human settlements. Herbivores damage the agricultural fields and carnivores kill the livestock and human beings. Crop damage, cattle killing and human death caused by wild animals are the three major problems which arise as a result of this conflict. Wild animals come in conflict with human being through-destruction and damage to crops, livestock depredation, loss of human life, damage to forestry plantations, damage to human constructions and cost of defending human properties

The problem of "man-animal conflict" exists all over the world. The situation for big cats is worse, including tiger, lion, leopard, snow leopard, jaguar and puma. Carnivore comes in conflict with human beings at three stages: competitions for prey, loss of human life and livestock depredation.

In developing countries like India, where the livestock husbandry is one of the major occupations of villagers living in and around protected areas, livestock depredation by big cats is not uncommon and causing considerable antipathy towards the predators. Persecution by human in response to livestock predation, both actual and potential, has been a major factor resulting in the disappearance of big cats from large areas of their former ranges in historical times, for example, the puma *Puma concolor* from eastern North America, the tiger *Panthera tigris* from most of China, and the lion *Panthera leo* from North Africa and southwest Asia (Novell & Jackson 1996).

Long-term conservation of wildlife in and around protected areas requires the support of the local people who experience the direct impacts of the establishment and management of those areas (Kiss 1990, Western & Wright 1994). Local people cannot provide their support until and unless problem of conflict exists or wild animals have negative impacts on local people. Management inputs to reduce the impact of predation on livestock is one of the most important tasks of managers of protected areas. Managers of protected areas and NGOs provide cattle kill compensation, to reduce the impact of this problem. But this is not the permanent solution of the problem. It is necessary to understand the relationship between the conservation needs and the aspirations of local people. So for the long-term solution of this problem, a thorough investigation of the problem is inevitable.

1.2 Importance of big cat

Big cats, being on the apex of food chain, play an important role in the homeostasis of the forest ecosystem and are the indicator of health and integrity of the environment. IUCN defines the big cats as Pantherine, including clouded leopard *Neofelis nebulosa*, snow leopard *Uncia uncia*, *Panthera* species and the marbled cat *Pardofelis marmorata*. In India, big cats are represented by five species-Tiger *Panthera tigris*, Asiatic lion *Panthera leo*, leopard *Panthera pardus*, clouded leopard, *Neofelis nebulosa*, and snow leopard *Uncia uncia*.

Ecologists who study the earth ecosystems and try to model their dynamics argue that the plant and animal communities that share our planet contribute to the stability and functioning of biological and chemical cycles that make life possible for us on this planet. Big cats, as tiger, are an integral part of these complex ecosystems (Karanth 2001). Tiger is at the apex of these ecosystems and therefore is the indicator of health of these ecosystems. So the conservation of tiger is necessary for the proper functioning of these ecosystems.

1.3 Study species (*Panthera tigris*)

1.3.1 Evolution and radiation

During the Mesozoic era (64-200 million years ago), the dinosaurs dominated the earth and mammals were as small as today's domestic cat. About 64 million years ago, at the end of Cretaceous, the dinosaurs along with other fauna become extinct and opened up the opportunity for the small mammals which were either insectivorous or omnivorous and much like the opossum (Martin 1989). In the tropical forests and swamps, mammals underwent explosive radiations to fill the niche left vacant, some diversified into large herbivores, some omnivores and other carnivores (Macdonald 1992). The early carnivores, known as miacids, flourished on earth during 60 to 65 million years ago. All the modern members of the order "Carnivora" are the descendants of the miacids.

Carnivores can be divided into four Ecomorphs namely civet like, cat like, mustelid like and dog like (Martin 1989). Cat like carnivores commonly stalk or ambush prey and kill prey by biting the back of the neck that was supplemented by learned behaviour of throat bite. The first true cat was *Pseudaelurus*, which evolved by 20 million years ago, and was scimitar-toothed felid ranging from a domestic cat to the size of a small jaguar. These carnivores were medium-sized ambushers of small vertebrates and adapted to open areas in the proximity of trees. Members of *Felidae* (true cats) are specialized hunters and they are purely carnivores.

The large cats, like the saber-toothed cats, were originated from the medium-sized ancestors and they flourished at the end of the Miocene when the World's climate changed in a way that revolutionized the lives of most carnivores. During that climate change, a new lineage of swifter and more agile cats rose, which are known as "pantherines". All the big cats including the tiger are their descendants (Macdonald 1992).

Tiger evolution has been determined from fossil evidences and molecular genetics techniques (Hemmer 1967, Kitchener 1999, Kitchener & Dugmore 2000). The tiger *Panthera tigris* belongs to a group of cat species called pantherines (Hemmer 1966). Cat of the genus 'panthera' probably evolved within last five million years or so (Hemmer 1976, Collier & O'Brien 1985, Wayne et al. 1989) The tiger belongs to the family *Felidae* and the genus *Panthera*, within which branching of tiger line has taken place even before lion (*Panthera leo*), leopard (*Panthera pardus*) and jaguar (*Panthera onca*) and were widely distributed over China and southeast Asia even before about two million years ago (Hemmer 1987, Kitchener 1999, Karanth 2003). The divergence of *tigris* line from the *Panthera* stock likely followed the Pleistocene radiation of the cervids and bovids in southeast Asia (Flerov 1960, Geist 1971) as the evolution of large-bodied forest ungulates (e.g. *Axix, Rusa, Cervus, Bos*) created a niche for large-bodied forest edge predators (Sunquist et al. 1999).

The centre of origin of the tiger is eastern Asia, within the present range of *P. t. amoyensis* (Hemmer 1987, Herrington 1987, Mazak 1981, 1996, Kitchener 1999). The oldest fossils of the tiger were recorded from northern China and Java (Hemmer 1971, 1976, 1987) and thought to date from the end of the Pliocene and the beginning of the Pleistocene and so may age up to two million years old (Hemmer 1967, 1987). These tigers were intermediate in size between modern Indian leopards and Sunda island tigers and represent large form of leopard or an ancestor of two or more of today's Panthera cats including tiger (Kitchener 1999). Abundant tiger fossils from the early middle to late Pleistocene have been recorded from China, Sunda and Java, but tiger fossils were only recorded in India, the Altai, northern Russia and elsewhere in the late Pleistocene (Brandt 1871, Lydekker 1886, Tscherski 1892, Dubois 1908, Zdansky 1928, Hemmer 1971, 1976, 1987). Hooijer (1947) place a decline in size of tigers during Pleistocene until present day, except those from the Russian Far East.

The late colonization of the tiger in Indian subcontinent is may be due to its absence from Sri Lanka, which was cut off by rising sea level at the beginning of the Holocene. Tiger had colonized the area either from northwest India (Heptner & Sludskii 1992) or a route from northeast Asia *via* Central Asia (Hemmer 1987, Mazak 1981).

Originated in East Asia, basic tiger phylogeny began differentiating after the primary dispersal of the species approximately two million years ago in two separate directions (Hemmer 1987, Mazak 1996). To the northwest tigers migrated through woodlands and along the river systems into southwest Asia. To the south and southwest, tigers moved through continental Southeast Asia, some was crossing the Indonesian islands and others finally reaching India (Nowell & Jackson 1996).

Chinese tiger may be considered as a relict population of 'stem' tigers living in the probable areas of origin of the species. It has distinctive primitive skull morphology including shorter cranial region and closely set, more forward facing eye sockets (Herrington 1987).

Tigers have the capacity to tolerate the high temperatures up to 48^0C and severe cold climates (-35^0C) but they are not adapted to the arid, water scarce environments in which lions and leopards still survive. They are distributed at altitudes ranging from sea level to 3,000 m and sometimes crossing Himalayan passes at 4,700 m above sea level (Karanth 2003).

1.3.2 Taxonomy

Taxonomy of felids have been undergone several revision since Linnaeus (1758), in his *Systema Nature*, laid down the foundation by naming genus *Felis.* Fisher (1817) coined the family name *Felidae* but Jardine (1834) was first who consider the relationship between species within the family *Felidae*. He differentiated five genera- Leo, Puma, Cynailurus, Lynchus and Felis and placed tigers in Felis. Classification by Jardine was crude and modern age of felid classification begins with Severtzov (1857-1858). He discussed the evolution of felids and emphasized the biogeography and its relationship to felid classification. He erected a number of new genus-level names as the genera and his classification includes five genera and 27 subspecies. Most of the names proposed by Severtzov, whether newly coined by him or adopted from earlier authors, are still in use for various grouping of felid taxa and in his classification, we see seed of a modern concept of Panthera in his genus *Panthera* and *Tigris*. Pocock (1917), later based on the structure of hyoid and digits, organized Felids into three monophyletic groups, the *Felinae* for small cats, the *Pantherinae* for large cats and the *Acinonychinae* for the cheetah (Werdelin 1996).

The classification of *Felidae*, as well as the genus Panthera as proposed by Wozencraft (1993) is most recent evaluation and has been adopted by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), World Conservation Monitoring Centre (WCMC) and IUCN/SSC cat specialist group. He recognizes three supragenic groups: the *Acinonychinae* (cheetah), the *Felinae* (smaller cats) and the *Pantherinae* (large cats) and put four species under the genus Panthera. These species are *P. tigris* (tiger), *P. leo* (lion), *P. pardus* (leopard) and *P. onca* (jaguar)

On the basis of geographic isolation and morphological differences, traditionally eight subspecies of *Panthera tigris* (*tigris* in South Asia, *virgata* in the Caspian region, *altaica* in Russia, *sondaica* in java, *amoyensis* in southern China, *balica* in Bali, *sumatrae* in Sumatra and *corbetii* in mainland Southeast Asia) are commonly recognized (Mazak 1981, Nowell & Jackson 1996). But the recent studies (Wentzel et al.

1999, Kitchener 1999, Kitchener & Dugmore 2000) based on genetic, morphological and biogeographically differences suggest that this traditional classification of "eight species" of tiger is not reliable. Kitchener (1999) recognized three subspecies of *Panthera tigris* (*tigris* in Mainland Asia, *virgata* in southeast Asia and *sondaica* in Java and Bali).

Out of eight traditionally recognized subspecies of tiger, three Bali (*P. t. balica*), Caspian (*P. t. virgata*) and Javan (*P. t. sondaica*) became extinct by 1940s, 1970s, and 1980s respectively. Recent synthesis on the basis of molecular genetics proposed a new subspecies of tiger- Malayan tiger *Panthera tigris jacksonii* (Luo et al. 2004). Presently tigers are distributed in fragmented populations and Dinerstein et al. (1997) identified 160 distinct and fragmented populations, which has been categorized into 76 Tiger Conservation Units (TCUs).

1.3.3 Distribution and status of tiger

In historic times, tiger were found all the way from the temperate zone forests of the Russian Far east to the tropical forests of the south western India (Karanth 2003). Geographic distribution of tiger was once extended across Asia from eastern Turkey to the sea of Okhotsik (Map 1). Its distribution range extended across 30 present day countries, stretching over 70 degrees of latitude and 100 degrees of longitude on the earth surface (Karanth 2001).

But now tigers survive only in isolated scattered population from India to Vietnam and in Sumatra, China and the Russian Far East and these tiger survive in 76 Tiger Conservation Units (TCUs) with different potential for the long term conservation of tiger (Map 2). Status of eight traditional subspecies of tiger is provided in table 1.1 as has compiled by Peter Jackson from different sources.

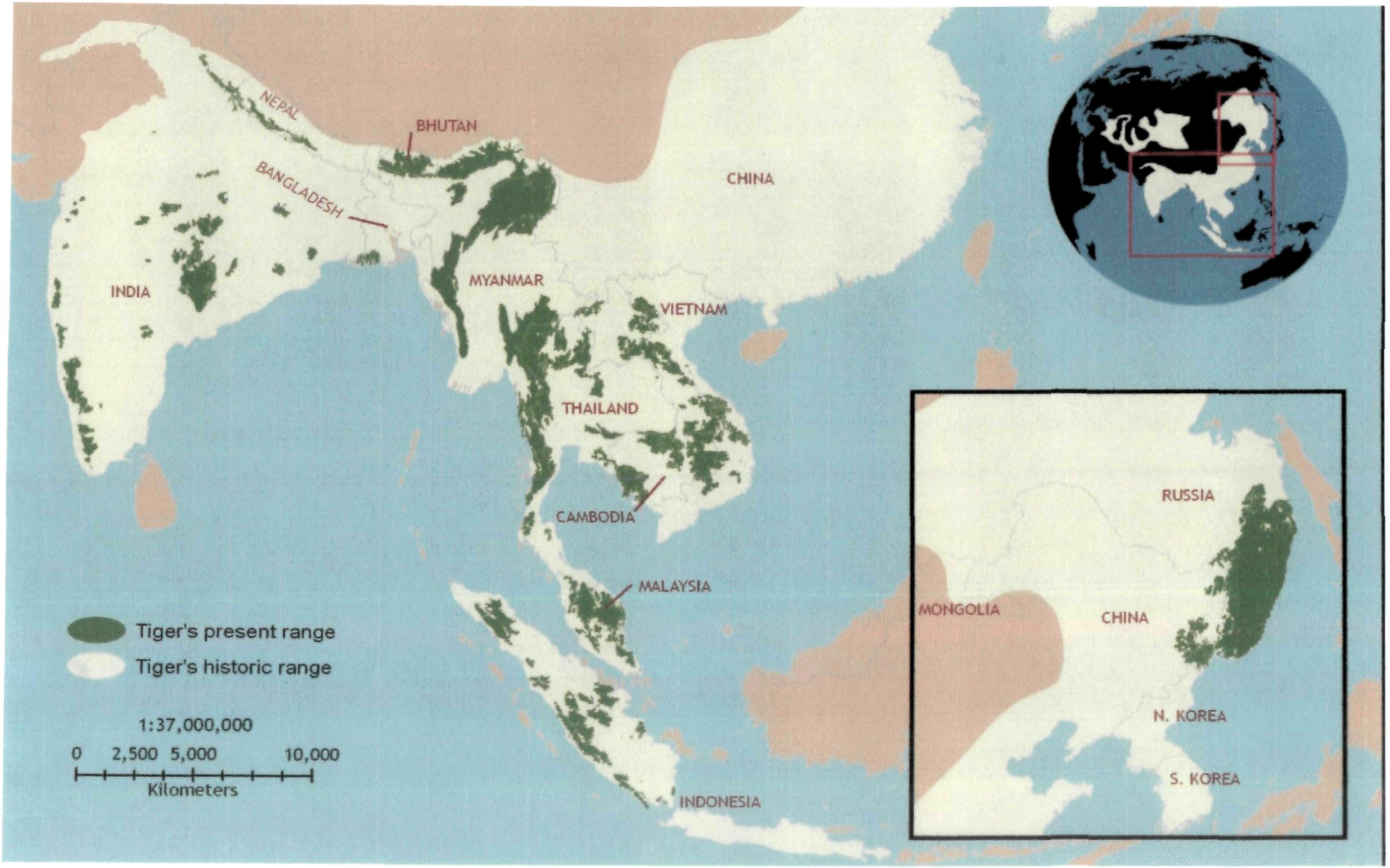
Table 1.1: Status of tiger *Panthera tigris* (Linnaeus 1758) in May 1998 (Modified from Peter Jackson)

Tiger subspecies	Minimum	Maximum	Source
Indian (Bengal) tiger *P. t. tigris* (Linnaeus 1758)	**3176**	**4556**	
Bangladesh	362	362(aduls)	Jalil 1998
*Bhutan	67 (adults)	81	McDougal& Tshering 1998
China	30	35	Wei 1998
India	2500	3750	Project Tiger 1993
Myanmar	124	231	Uga & Thang 1998
*Nepal	93	97(adults)	Govt. of the Kingdom of Nepal 1997
Caspian (Turan/Hyrcanian) tiger *P. t. virgata* (Illiger 1815)			
Formerly Afghanistan, Iran, Chinese and Russian Turkestan, Turkey	**Extinct 1970s**		
Amur (Siberian/Ussuri/Manchurian/northeast China) tiger*P. t. altaica* (Temminck 1844)	**360**	**406**	
China	30	35	Wei 1998
Korea (North)	<10	<10	Pak U-II 1994
*Russia	330 (adults)	371(adults)	Matyushkin et al. 1996
Javan tiger *P. t. sondaica* (Temminck 1844)	**Extinct 1980s**		

Tiger sub-species	Minimum	Maximum	Source
South China (Amoy) tiger *P. t. amoyensis* (Hilzheimer 1905)	**20**	**30**	Wei 1998
Bali tiger *P. t. balica* (Schwarz 1912)	**Extinct 1940s**		
Sumatran tiger *P. t. sumatrae* (Pocock 1929)	**400**	**500**	Wartaputra et al. 1994
Indo-Chinese tiger *P. t. corbetti* (Mazak 1968)	**1227**	**1785**	
Cambodia	150	300	Samith et al. 1995
China	30	40	Wei 1998
Laos	Present		
Malaysia	491	510	Abdul 1998
Myanmar Eastern	106	234	Uga & Thang 1998
Thailand	250	501	Rabinowitz 1993, Govt. of the Kingdom of Thailand 1998
Vietnam	200	200	Bao et al. 1995
Totals	**5183**	**7277**	
Rounded totals (nearest 500)	**5000**	**7000**	

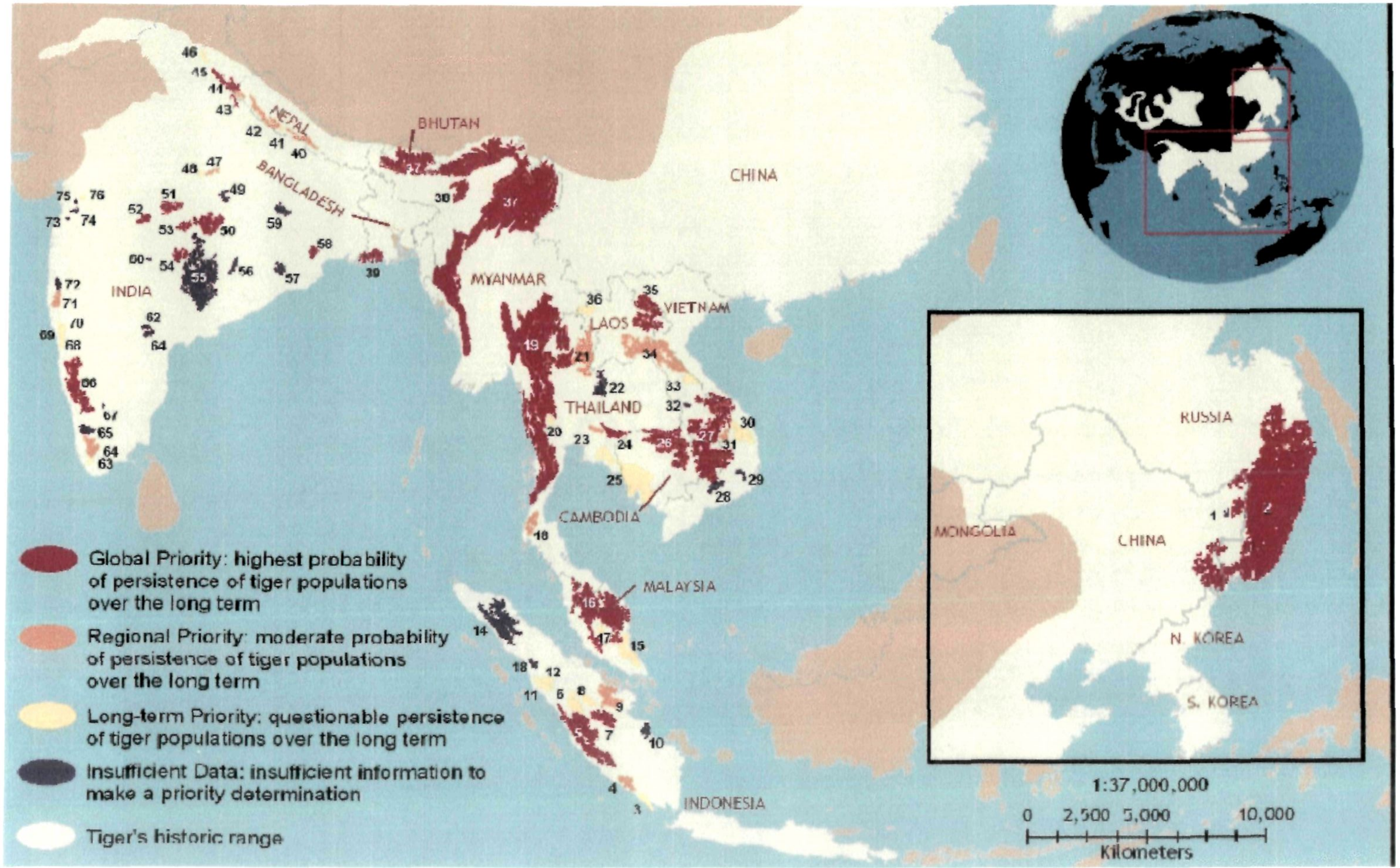
Table compiled by Peter Jackson, Chairman, Cat Specialist Group, The World Conservation Union (IUCN).

***Figures for Bhutan, Nepal and Russia are for adult tigers counted. Tiger specialists consider such figures more realistic because many cubs are unlikely to survive to maturity.**



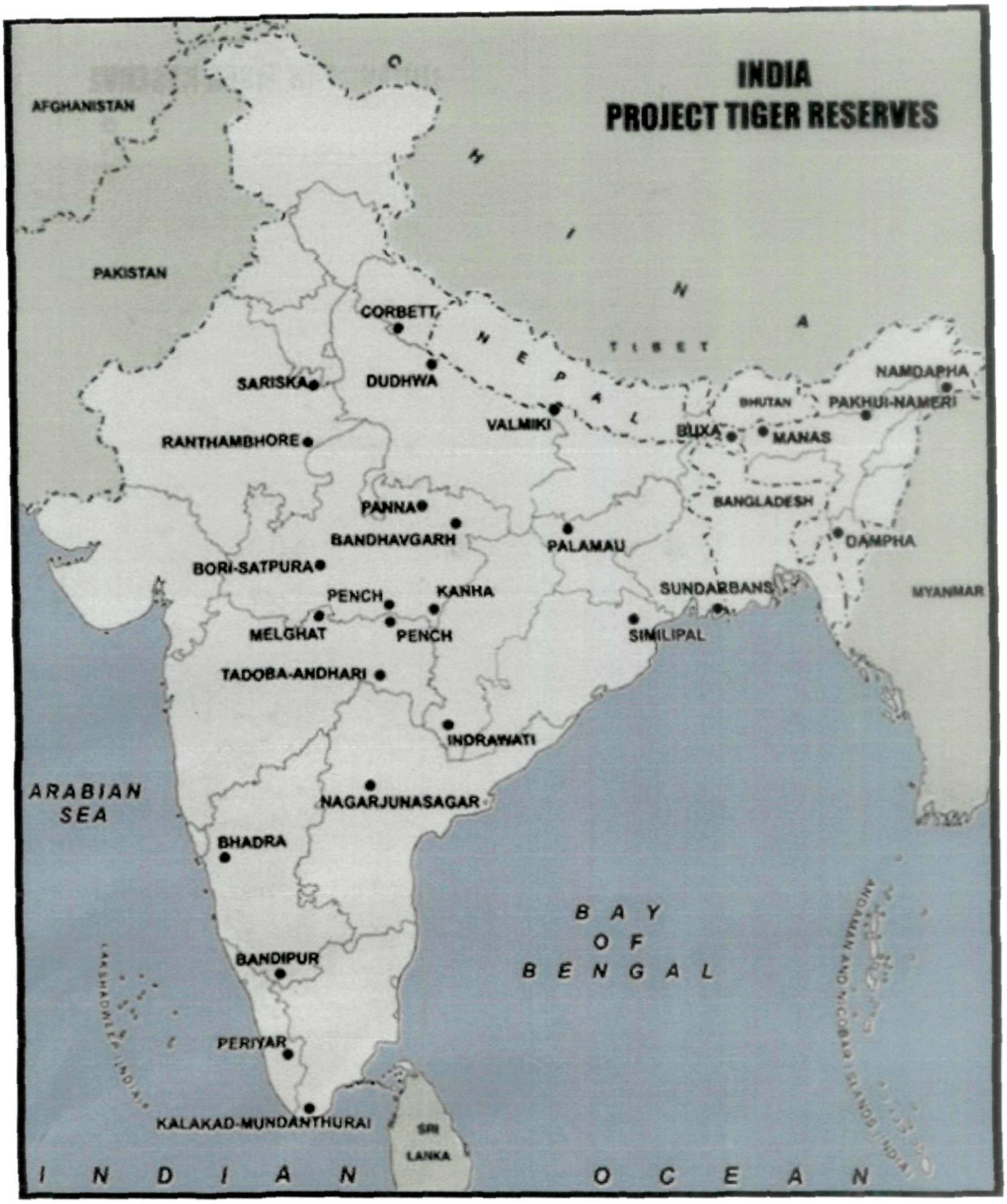
Source:* http://www.savethetigerfund.org *as viewed on November 11, 2008

Map 1: Present and historic range of tiger



Source:* http://www.savethetigerfund.org *as viewed on November 11, 2008

Map 2: Spatial distribution of present potential tiger habitats



Source: http://www.projecttiger.nic.in as viewed on November 10, 2008

Map 3: Location of different Tiger Reserves in India

Table 1.2: Population of tigers in the different Tiger Reserves

S. .No.	TIGER RESERVE	1972	1979	1984	1989	1993	1995	1997	2001-02
1.	Bandipur (Madhya Pradesh)	10	39	53	50	66	74	75	82
2.	Corbett (Uttarankhand)	44	84	90	91	123	128	138	137
3.	Kanha (Madhya Pradesh)	43	71	109	97	100	97	114	127
4.	Manas (Assam)	31	69	123	92	81	94	125	65*
5.	Melghat (Maharashtra)	27	63	80	77	72	71	73	73
6.	Palamau (Jharkhand)	22	37	62	55	44	47	44	32
7.	Ranthombore (Rajasthan)	14	25	38	44	36	38	32	35
8.	Similipal (Orissa)	17	65	71	93	95	97	98	99
9.	Sunderbans (West bengal)	60	205	264	269	251	242	263	245
10.	Periyar (Kerala)	-	34	44	45	30	39	40	36
11.	Sariska (Rajasthan)	-	19	26	19	24	25	24	22
12.	Buxa (West Bengal)	-	-	15	33	29	31	32	31
13.	Indravati (Madhya Pradesh)	-	-	38	28	18	15	15	29
14.	Nagarjunasagar (Andhra Pradesh)	-	-	65	94	44	34	39	67
15.	Namdhapa (Arunachal Pradesh)	-	-	43	47	47	52	57	61

S. .No.	TIGER RESERVE	1972	1979	1984	1989	1993	1995	1997	2001-02
16.	Dudhwa (Uttar Pradesh)	-	-	-	90	94	98	104	76*
17.	Kalakhand (Tamil Nadu)	-	-	-	22	17	16	28	27
18.	Valmiki (Bihar)	-	-	-	81	49	N.R.	53	53
19.	Pench (Madhya Pradesh)	-	-	-	-	39	27	29	40
20.	Tadoba (Maharashtra)	-	-	-	-	34	36	42	38
21.	Bandhavgarh (Madhya Pradesh)	-	-	-	-	41	46	46	56
22.	Panna (Madhya Pradesh)	-	-	-	-	25	22	22	31
23.	Dampha (Mizoram)	-	-	-	-	7	4	5	4
24.	Pench (Maharashtra)	-	-	-	-	-	10(1994)	-	14
25.	Bhadra (Karnataka)	-	-	-	-	-	-	-	35
26.	Pakhui - nameri (Arunachal Pradesh-Assam)	-	-	-	-	-	-	-	26 Nameri
27.	Bori-Satpura-Pachmari (Madhya Pradesh)	-	-	-	-	30	-	-	35
	Total	268	711	1121	1327	1366	1333	1498	1576

Source: http://projecttiger.nic.in as viewed November 10, 2008

1.4 Indian tiger (*P. t. tigris)*

1.4.1 Status

Indian tiger, *P. t. tigris* is found in India, Bangladesh, Bhutan, China and Myanmar. India holds the largest population of tiger and supports more than half of the world tiger population and 82% (3750 individuals) of Bengal tiger (Nowell & Jackson 1996). According to Johnsingh and Goyal (2005) tiger population in the country would be very close to 2000 individuals. But recently, Jhala et al. (2008) reported that India has only1411 tigers distributed in 6 landscape complexes. Tigers are found in an array of forests of India and more than 90% are concentrated in 13 states Andhra Pradesh, Bihar, Orissa, Rajasthan, Maharastra, Karnataka, Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Tamilnadu, West Bengal and Assam (Melkani 2001). It is believed that India supported about 40,000 tigers at the beginning of 20th century but it was declined to around 1880 in 1972.

Considering this fact, efforts to launch Project Tiger were initiated and tiger was adopted as flagship species under which an array of habitats was protected to conserve the whole diversity of animals sharing the ranges with tiger. On April 1st 1973, Project Tiger was launched from Corbett Tiger Reserve and initially nine distinctly different ecosystems ranging from Corbett in Himalayan foothills of the then Uttar Pradesh to the Sundarban delta of West Bengal and Simlipal in Orissa to the semi arid scrub forest of Ranthambore in Rajasthan were declared as Tiger Reserve for the conservation of tiger. Twenty eight protected areas enjoying the benefit of protection under the Project Tiger Scheme and provide protection to representative samples of natural forests, which along with tiger conserve all the wild animals. These Tiger Reserves (Map 3) extend in 17 states and cover 37,761 km^2 tiger land (Anon 2005). Table 1.2 provides the status of tiger in different Tiger Reserves of India.

After Sariska crisis, following recomdedations of Tiger Task Force, established by Prime Minister, National Tiger Conservation Authority was estableshed in December 2005 to tailor better strategies for the conservation of tiger.

1.4.2 Habits

A. Communication

Tiger is the largest member of cat family and is solitary animal that lives at very low densities (Sunquist 1981, Sunquist et al. 1999). To seek out or to avoid one another, tigers communicate with each other through the chemical, visual and vocal signals (Karanth 2003). During the patrolling of their territory, they leave message through these signals and after receiving these message other individuals act accordingly. Through these signals they communicate their ownership of territory, time of estrous and their social dominance. These signals include scrape marks, scats, urination and scratch mark on the trees. Through these signals they maintain their social organization and avoid fatal encounter with each other.

B. Reproductive biology

Tiger mates throughout the year but it was observed that mating takes place more frequently from November to April (Sankala 1967, Schaller 1967). Tigresses advertise their oestrous status through increased bouts of roaring and scent markings that help male tigers to know their sexual maturity and find them. Mating period lasts from 2-7 days and involves dozens of copulation of about 15 seconds duration every day and after this the two individuals go their own separate ways (Karanth 2003).

After a gestation period of 102-108 days, a tigress gives birth to blind and helpless cubs in secluded hideout and aggressively protect from other predators and tigers. Litter size of tiger is 2-5 (average 3) (Smith & Mac Dougal 1991, Karanth 2003), but observation of association of cubs with mother indicates that 2-3 is the commonest (Sankala 1978). Sometimes under the compulsion of temporary hormonal imbalance, a tigress may kill or even eat her newborn cub (Karanth 2003). At the age of 3.4 years a female is sexually mature and ready to breed while the males breed at the age of 4.8 years. After getting matured, adult tiger disperses away from the home rage of mother.

C. Activity and hunting

During the night, tigers have superior vision in comparison of prey species that's why they primarily hunt after dark (Sunquist 1981, Karanth & Sunquist 2000). Mostly activity starts at dusk and they are active until the dawn. During the hot hours of the day, they rest under sheds or lie up in the water because tigers are not able to tolerate the high temperature.

During the night tiger moves on the roads and forest trails in search of prey animals. But sometimes, they lie in ambush at localities favoured by prey species, like water holes, clearings or salt licks (Karanth & Sunquist 2000). After the detection of prey animals, tiger stalks it silently using every piece of cover and after a sudden rush; finally dispatches the prey (Seidensticker & McDougal 1993, Karanth & Sunquist 2000). Tiger usually attacks the prey from the flanks or rear and knocks it down by impact of its momentum and by grappling with its forelimbs (Karanth 2003). Simultaneously, it tries to bite the prey animal's throat or nape to immobilize and finally killed by strangulation or by rupturing of the cervical vertebrae, spinal cord, brain case or major blood vessels (Seidensticker & McDougal 1993, Karanth 2003).

D. Feeding

Mostly tigers start feeding from the hind portion of prey animals but cubs sometimes start feeding from the front and other body parts of the prey. During the feeding, they do not feed on the intestinal portion and separate it from the rest of the body of prey. Tiger drags its kills and hides the carcass in dense cover and stay close to protect aggressively it from the other predators and scavengers (Karanth & Sunquist 2000, Karanth 2003). Compelled by hunger, tigers scavenge kills made by other tigers or by other predator species (Karanth 2003).

1.4.3 Problems

Tiger has been adopted as flagship species and under tiger conservation movement; effort was made to conserve the overall bio-diversity (Karanth 1995). Despite all the efforts, chances of long-term survival of this charismatic species decrease under the adverse pressure of several problems such as habitat fragmentation, degradation, destruction and loss, illegal poaching of tigers and their prey species, slackening protection effort, genetic inbreeding and natural calamities. The need of ever increasing human and livestock population put the immense pressure on the tiger habitats and pose threat to tiger survival. Nyhus and Tilson (2004) documented four foremost threats for the continued decline of tiger 1) Habitat degradation, fragmentation and finally loss of habitat 2) depletion of tiger natural prey base 3) illegal poaching of tiger and 4) finally retaliatory killing of tiger in response of threat to their livestock and human life. Most of the tiger populations are fragmented and estimated population size vary from less 20 to 200 breeding individuals. These fragmented populations are more vulnerable to extinction (Shaffer 1981, Frankel & Solue 1981).

A. Habitat degradation, fragmentation and loss

Tiger is large bodied, top predator in food chain and needs large intact-forested areas to meet basic requirements. Ever increasing demands of a densely populated and expanding human and cattle population put the immense pressure on the prime forested areas (Melkani 2001). Under the influence of biotic pressure such as livestock grazing, collection of fuel wood and fodder, tiger habitats get degraded in terms of quality. These degraded habitats become less productive in terms of abundance of natural prey base and have depressing impact on the reproductive success of tigers.

Due to the developmental activities such as construction of roads, railway track and infrastructure for human being tiger habitats fragmented and remaining populations survive in the isolated small patches surrounded by humans. Most of the protected areas created for the conservation of tigers are too small and are not able to support the viable population of tiger. Chances of long-term survival of tiger in these small-protected areas are very grim.

Clearing of forested areas for agriculture, industrial development and encroachment on the forestland directly result in the loss of tiger habitat. Loss of tiger habitat results in the decrease of tiger range. Loss of habitat combined with degradation and fragmentation of tiger habitats is considered to be the prime threat for the well being of tiger.

B. Poaching

Illegal poaching and hunting of tiger is also widely considered as the chief threat to the long-term survival of this magnificent species (Seidensticker 1997). In the past, people hunted tigers most commonly to protect livestock and less often for protecting human lives (Karanth 2001) and for sports to collect their skin, teeth or claws as trophies and for commercial purposes. Sometimes tigers also died in snares and traps placed by local people to catch other wild animals. But tiger poaching for trade of tiger body parts, particularly bones for use in traditional Chinese medicine, is now considered most immediate danger for the long-term survival of world's tiger populations (Mills & Jackson 1994, Jackson & Kemf 1996, Hemley & Bolze 1997). Although CITES has banned the commercial international trade in tiger parts and its derivatives since 1975 but there are evidences of a growing trade of fake tiger bones in China (Hemley & Mills 1999).

China already lost most of its tigers and puts pressure on the seven bordering tiger range countries- Bhutan, India, Laos, Myanmar, Nepal, Russia and Vietnam. Most border crossings are not well policed and low per capita income on all sides makes poaching, smuggling and black market trading lucrative options (Hemley & Mills 1999). An adult male tiger brings back around US $15,500 to 20,000 for the people involved in the poaching of tiger (Nowell 2003).

A comprehensive assessment of potential tiger habitats revealed that more than 85 % of tiger habitats are subjected to moderate to high poaching pressure (Dinerstein et al. 1997). In long term, tigers are at high risk of extinction from poaching, but there is empirical evidence that hunting pressure among big cats may not have high negative impact on their densities (Lindzey et al. 1992, 1994). Martin and Meulenaer (1988) pointed out that hunting could drive big cats populations into rapid extinction, only if it exceeds threshold level set by habitat quality and reproductive potential of the species.

C. Prey depletion

Besides poaching and hunting of tigers, depletion of natural prey base of tiger is also a principal threat responsible for decline of tigers all over its range. Abundance of prey decreased under combined pressure of hunting by local people and forest-based activities of local people. Status of prey base is the critical determinant of tiger status, distribution and population viability of tiger (Karanth & Stith 1999, Karanth 2001, Melkani 2001). Recent studies (Karanth & Sunquist 1995, Miquelle et al. 1996, Karanth & Nichols 1998) indicate that densities of different sized ungulate prey largely mediate abundances of tigers and other similar predators. Although habitat shrinkage has been a historically well known factor responsible for tiger population decline (Schaller 1967, Mountfort 1981, Thapar 1992) but recent assessment (Wikramanake et al. 1999) based on forest cover maps show that extensive stretches of potentially suitable tiger habitats still exist in most range countries. Across its range, about 1,500,000 km^2 of habitat is potentially suitable for tiger but they occupy a minute potion of it which indicates that some other factor is behind the decline of tigers (Karanth 2001). Under the pressure of over hunting of tiger natural prey by human, densities of tigers also decrease. Due to the insufficiency of natural prey base, the carrying capacity for breeding females decreases and cub survival is reduced and tiger population size decreases rapidly (Karanth & Stith 1999).

Due to the paucity of natural prey, tiger moves towards the human settlements in search of prey and kill the livestock of local people living in and around the tiger habitats. Local people become antagonistic towards the conservation of tiger and sometimes poison carcass of livestock killed by tiger and after feeding on poisoned carcass tiger dies. This problem of human-tiger conflict put pressure on tiger populations and problem for the tiger conservation.

D. Weak law enforcement

Under the umbrella of Wildlife (Protection), Act 1972 and CITES, tigers have the full protection. CITES banned the trade in tiger parts and their use in traditional Chinese medicines, but undercover investigators obtained tiger products in various places in China after the imposition of ban. Despite the ban and all effort from conservation community, there is evidence of continuing use of tiger parts in traditional Chinese medicines and trade in tiger parts flourish. A major problem for law enforcement authorities is to prove that medicine contain tiger or other forbidden animal products (WWF 1999). Another problem is that forest personal are not legally sound to deal with people involved in the trade of wild animals. There are loophole in judiciary processes and culprit usually take the benefit of these loop holes.

E. Natural disaster

Along with different man made problems, natural disasters also have negative impact on the tiger populations. Fragmented and small population are vulnerable to natural disasters like forest fires, flood, hurricane and epidemic diseases (Khan 2004). These natural disasters have more pronounced depressing impact on the survival rate of cubs since they are helpless and totally depend on their mother. In absence of mother they died due to these natural disasters.

1.5 Significance of study

Big cats, being at the apex of the food chain, play an important role in the homeostasis of the forests ecosystem and are indicators of the health and integrity of the environment. Being at the top of the food chain, tigers (*Panthera tigris*) have the capability to regulate the functioning of the ecosystem in which they survive. The well being of tigers in wild habitats ensures the security of the proper functioning of our forest ecosystems. This means that by conserving the tiger, we can conserve the whole ecosystem with all its living entities.

Wild lands around the world were once colonized by the eight subspecies of tiger and this magnificent animal was very common over its wide distribution range. But under pressure of human made forces, habitat destruction, fragmentation, poaching of tigers and its prey species, poisoning of carcasses of cattle killed by tigers etc, three subspecies of tiger disappeared from the picture of the world. Of the remaining five subspecies, their total population is estimated to be between 4600 and 7700 individuals (Nowell & Jackson 1996). The subspecies ranging in the forests of the Indian subcontinent (India, Bangladesh, Nepal and Bhutan), is the Bengal tiger (*P. t. tigris*) and it is the last hope of survival of tigers in the wild since the other four subspecies have very small isolated populations. But the combined effect of habitat destruction, poaching of tigers and its prey species and human-tiger conflict is forcing this species of tiger to the brink of extinction.

The Indian Government and the people of the world have paid great attention to the conservation of the Bengal tiger. Considerable effort and resource has gone into tiger conservation in the last three decades. The Indian Government launched the tiger as the flagship species and considered it as the indicator of health and prosperity of Indian forests and on 1st April 1973 launched the "Project Tiger" for the conservation of the tiger and the biodiversity associated with it. This most successful conservation project of India was inaugurated from the Corbett Tiger Reserve (CTR). Protected areas designated as tiger reserves under this scheme, have played an important role in saving the tiger from extinction. However, most of the tiger reserves in India face the problem of human-tiger conflict which has arisen due to lack of compatibility between conservation interests of protected areas and needs and aspirations of local people living in and around the tiger reserves. The scale and magnitude of human-tiger conflict varies between different tiger reserves and in some reserves the problem of human-tiger conflict has been reported to be very severe. There is general lack of quantitative and objective assessment of the nature of human-tiger conflict across different tiger reserves and there is even greater lack of understanding of factors responsible for occurrence of conflict on spatial and temporal scale.

The Corbett Tiger Reserve (CTR) in Uttarakhand is India's oldest National Park and it constitutes a significant conservation unit for the tiger under the "Project Tiger" scheme of the Government of India. Except for some gujjar settlements, there is no human disturbance in the core zone of Corbett Tiger Reserve. The buffer zone of the Corbett Tiger Reserve and its adjoining areas has 140 villages and *gujjar deras* with a human population of 77,803 and an equal number of cattle populations

(58,534). There is severe human-tiger conflict in the buffer zone of the CTR. Tiger in the buffer zone injures and kills a large number of cattle every year. The severity of this conflict can be gauged from the fact that there were 283, 344 and 303 cattle killed and injured by tigers alone during 1998, 1999 and up to November 2000 respectively (The Corbett Foundation 2000). The number of cattle killed by tigers was 199, 267 and 214 respectively, during these years. The Corbett Foundation has been running a cattle compensation programme since 1995 where it provides financial assistance as compensation for cattle injured and killed to the cattle owner. Since October 1997, the Corbett Foundation is implementing the compensation scheme with the tiger conservation programme of WWF- India.

The ecology of tiger and the problem of large scale cattle depredation by tigers in the buffer zone of CTR have not been investigated so far. Such a study would provide basic data, which can be utilized by park managers to evaluate long-term mitigation strategies to reduce the human-tiger conflict and to tailor better management strategies in the CTR. In fact significant reduction in human-tiger conflict, effective curbs on the poaching of tigers, better management policies, raising conservation awareness in local populations and provision of alternative of fodder and fuel to villagers dependent on tiger habitats can only ensure the long term conservation of the tiger. To achieve these goals it is crucial to have a thorough understanding of all aspects of tiger ecology and the socio-economic profile of the people living in and around tiger habitats. The proposed study aims to investigate the ecology of tigers in and around the buffer zone of the Corbett Tiger Reserve.

1.7 What happened during the time I was completing my field work?

During the time of my Ph. D. thesis there were ups and downs in the tiger conservation within our country. The first nationwide scientific survey of the tiger within our country, the all time low number of tigers within the country, local extinction of tiger from the Sariska and the reintroduction of the tiger to the Sariska.

First time in the history of the conservation, we used modern techniques to count the number of tiger witin the country. The previously used pug mark census technique was changed by the advanced technique of camera trapping based on the principle of capture-recapture models. The estimate was around the 1411 tigers within the country. The number indicates 50% decline in the offical figures of the tiger numbers within the country. The decline may or may not be the actual decline, but it can perhaps attribute to the modern sophisticated techniques. The fall of tiger population have put nation on toes to change the project tiger as an authority. The seperate authority gave boon to the tiger conservation within our country.

The study period also included the loss of tigers from the Sariska Tiger Reserve. Govt. of India was offically announed that there are no tigers in the Sariska Tiger Recerve. First time in the history of tiger conservation we lost tigers. But the conservation efforts by NTCA and Rajasthan Forest Department with Scientific Collaboration from Wildlife Institute of India, tigers were back to Sariska within a year or so, first scientific reintroduction of tigers in Indian History and second in the world history.

Being the country where consevation is too difficlut with demand on food more than expected and in the stages of the developing nation, we still manage to conserve tigers -a challenge we accepted and we are doing it at the best levels we can afford to do.

1.8 Objectives of the study

1. To study the habitat conditions and abundance of prey species of tigers in buffer zone of the Corbett Tiger Reserve.
2. To study the abundance and seasonal habitat use of tigers in buffer zone of the Corbett Tiger Reserve.
3. To study the feeding ecology of tigers in buffer zone of the Corbett Tiger Reserve.
4. To study the socio-economic conditions and level of tiger-human conflict in and around buffer zone of the Corbett Tiger Reserve.
5. To suggest strategies for mitigation of tiger-human conflict and long term conservation of tiger in the Corbett tiger Reserve.

2.1 Genesis of Reserve and its legal status

The Corbett Tiger Reserve (CTR) is one of the very significant and prestigious conservation units for the conservation of tiger in India. Prior to the years of 1815-20 of British rule, the forest of CTR was the private property of local rulers. Even after their ownership had passed into British hand, the Government paid little or no attention towards the conservation and management of forest and wildlife until 1858. Resources of these forestlands were being utilized for the benefit of British Government without any management practices and large tracts of natural forest were cut down by the British government. Under the pressure of ever increasing human and livestock population and rampant cutting of forest for development activities, quality of forest degraded drastically and area under these forests decreased rapidly. It was only in 1858 that Major Ramsay, with vision and sensitivity towards the importance of forest, proposed first comprehensive management plan to the protection and management of these valuable assets. In 1861-62, he banned farming in the lower *Patalidun* valley and drove out *khattas* (cattlesheds) from the forested areas. In 1868, forest department took the responsibility of the forest and in 1879; it declared them as reserved forest under the Forest Act and managed under various working plans and interim schemes. By 1894 after thirty-six years of keen and strict management, the condition of the forest began to improve.

For the first time in 1907, Sir Michael Keen referred to the possibility of turning these forests into a game sanctuary. In 1916, E. R. Stevans, the then Divisional Forest Officer of Ramnagar, once again raised the subject. In 1917, Smythies tentatively proposed the declaration of the area as sanctuary. Later in 1934, the Governor, Sir Malcolm Hailey, lent his support to the proposal to create a sanctuary. Finally, on 8th August 1936, it declared as the Hailey National Park under the United Province (Uttar Pradesh) National Parks Act, and became not only India's but also Asia's first National Park. After India gained her independence, the name was changed to Ramganga National Park in 1952 on the name of the river Ramganga, the lifeline of Corbett National Park. Finally, in 1957, it was rechristened as Corbett National Park to commemorate the memory of famous naturalist, Jim Corbett. Initially, it covered an area of 323.75 km^2. An additional area of 197.07 km^2 was added in 1966 and spreading over an area of 520.82 km^2. On 1st April 1973, to protect the tiger and its habitat, the Government of India launched the Project Tiger and was then inaugurated from the land of Corbett National Park on 1st February 1974. Until 1991, Corbett National Park and Corbett Tiger Reserve were synonymous and in 1991 Sonanadi Wildlife Sanctuary and reserve forest areas from Ramnagar and Terai west forest divisions were also included to make it present Corbett Tiger Reserve.

2.2 Location

The Corbett Tiger Reserve is located in the foothills of Himalayas in the civil districts of Nainital, Pauri Garhwal, and Almora of Uttarakhand state of India (Map 3). The area extends from 29.34^0 to 29.81^0N and 78.55^0 to 79.15^0E. It covers part of lower central Himalayan foothills immediately north of the terai, known as the Siwaliks, which form part of the Bhavar tract. The CTR within its boundary incorporate areas of the Corbett National Park, Sonanadi Wildlife Sanctuary, and buffer zones for both units. At present CTR covers an area of 1288.32 km^2, which includes an area of 520.82 km^2 of Corbett National Park, 301.18 km^2 of Sonanadi Wildlife Sanctuary and 466.32 km^2 of buffer area for both units.

2.3 Management

Within the Corbett Tiger Reserve, for the better management, two different management units recognized as Ramnagar Tiger Reserve (RTR) Division and Kalagarh Tiger Reserve (KTR) Division. These units differ in terms of their vegetation, topography, rainfall inputs and degradation of habitats. Legally the CTR is divided into two zones: Core zone and Buffer zone. However, in order to maintain the ecological balance and anthropogenic pressure, area of the CTR was classified into three basic zones- Core zone, Tourism zone and Buffer zone. Core zone is entirely protected for the wild animals with no human activity permitted except management by forest department. Tourism zone is for the recreational and tourist activities without any extraction of forest products and consist of overlapping areas of both core zone and buffer zone. Three mutually exclusive tourism zones: Dhikala, Bijrani and Jhirna tourism zones were demarcated in the CTR (Map 5). Buffer zone was created to fulfill the basic needs of local people and was necessary to gain the support and cooperation of local people. Local people were permitted to graze their livestock, collect fodder for livestock, fuelwood, thatching material and other NTFPs (non-timber forest products) from the buffer zone of the CTR. The CTR is surrounded with a rich buffer zone on all sides except along an 11 km stretch, between Khara gate and Kalagarh, on the sourthern boundary (Core area), where the boundary comes in direct contact with agricultural fields of Bijnore district of Uttar Pradesh and does not have any buffer forest. These above three zones are created to achieve the necessitate objectives of the protected area.

2.4 Intensive study area (Buffer zone of the CTR)

Present study was conducted in two phases, the first phase concentrates on the different aspects of tiger-human conflict and habitat conditions available for tigers whereas the second phase concentrate on the ecology of tiger. During the first phase, I also covered the areas adjoining to the buffer zone of the CTR to study the conflict and prevailing socio-economic conditions in and around the buffer zone of the (CTR Map 6). While during the second phase I selected eight forest blocks of the buffer zone located on south-eastern boundary of the CTR. Depending upon the location of cattle kill, adjoining areas up to 50 km from the buffer zone boundary of the CTR were also covered. Map 6 shows the location of BZ with boundaries and names of forest blocks (FB) covered under the present study and table 2.1 provides names of these blocks and the area of each forest blocks.

Table 2.1: Details of forest blocks in the buffer zone of the Corbett Tiger Reserve

Serial Number	Name of the Forest Block	Area of the Forest Block (Ha)
1	Adnala	867
2	Bijoragadh	1560.9
3	Dhaulkhand	2801.2
4	Dhela Bhabar	1894.4
5	Dhulwa (E)	2126.7
6	Dumunda (E)	1835
7	Dumunda (W)	2525.6
8	East Mandal	1848.3
9	Era	783.9
10	Haldgaddi	4345.1
11	Jamaria (W)	1459.6
12	Kalagadh	469
13	Kalakhand	772.5
14	Kalushahid	2652.3
15	Kartia	261.8
16	Khansur	3454
17	Kugadda	1301.5
18	Lohachaur	1283
19	Malani	667.3
20	Mandal	1895.6
21	Nalkatta	1651.9
22	North Jashpur	1465.3
23	Pakharau	1520.4
24	Phooltal	3555.2
25	Sawaldeh Bhabar	2517.5
26	Sawaldeh Hill	1242.8

Ha = Hectare.

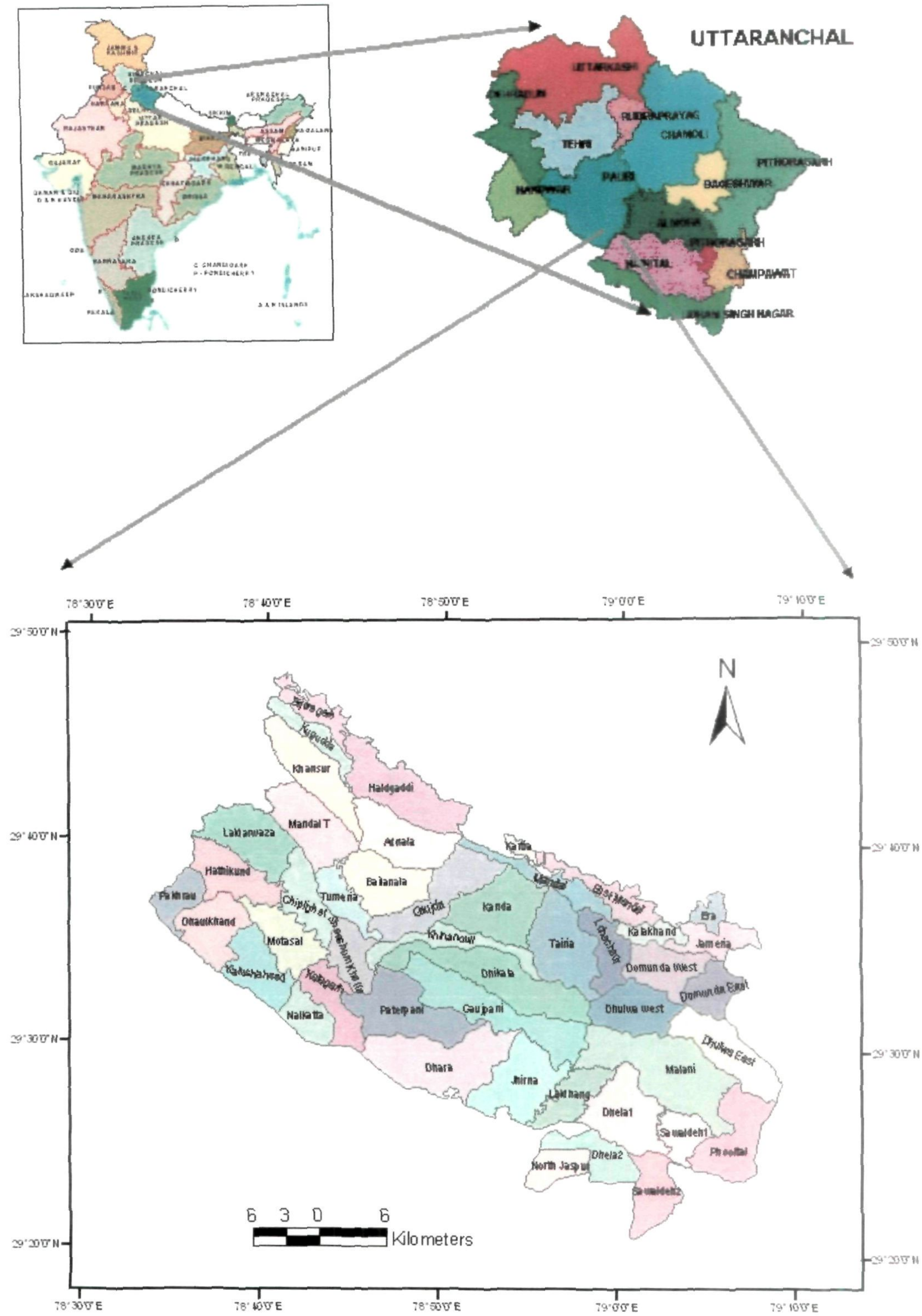
Eight forest blocks (FB) located on the southeastern boundary of buffer zone of the CTR were selected for the ecological studies on tiger. Table 2.2 provides names of these blocks and the area of each forest block.

Table 2.2: Details of forest blocks in the buffer zone of the Corbett Tiger Reserve selected for the study of tiger ecology (Second phase)

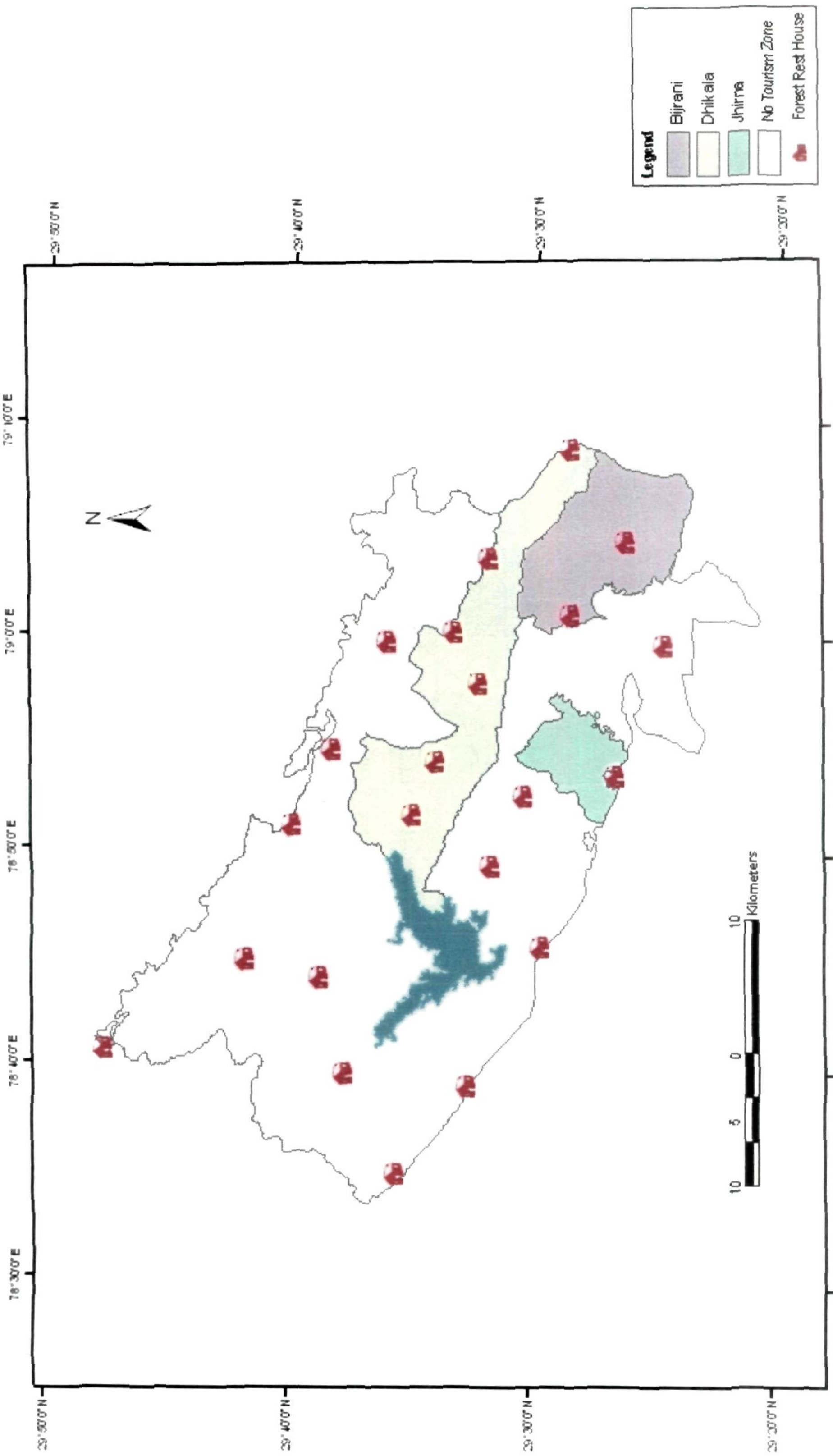
Serial Number	Name of the Forest Block	Area of the Forest Block (Ha)
1.	Dhela Bhabar	1894.4
2.	Dhulwa (E)	2126.7
3.	Dumunda (E)	1835
4.	Jamaria (W)	1459.6
5.	North Jashpur	1465.3
6.	Phooltal	3555.2
7.	Sawaldeh Bhavar	2517.5
8.	Sawaldeh Hill	1242.8

2.5 Topography

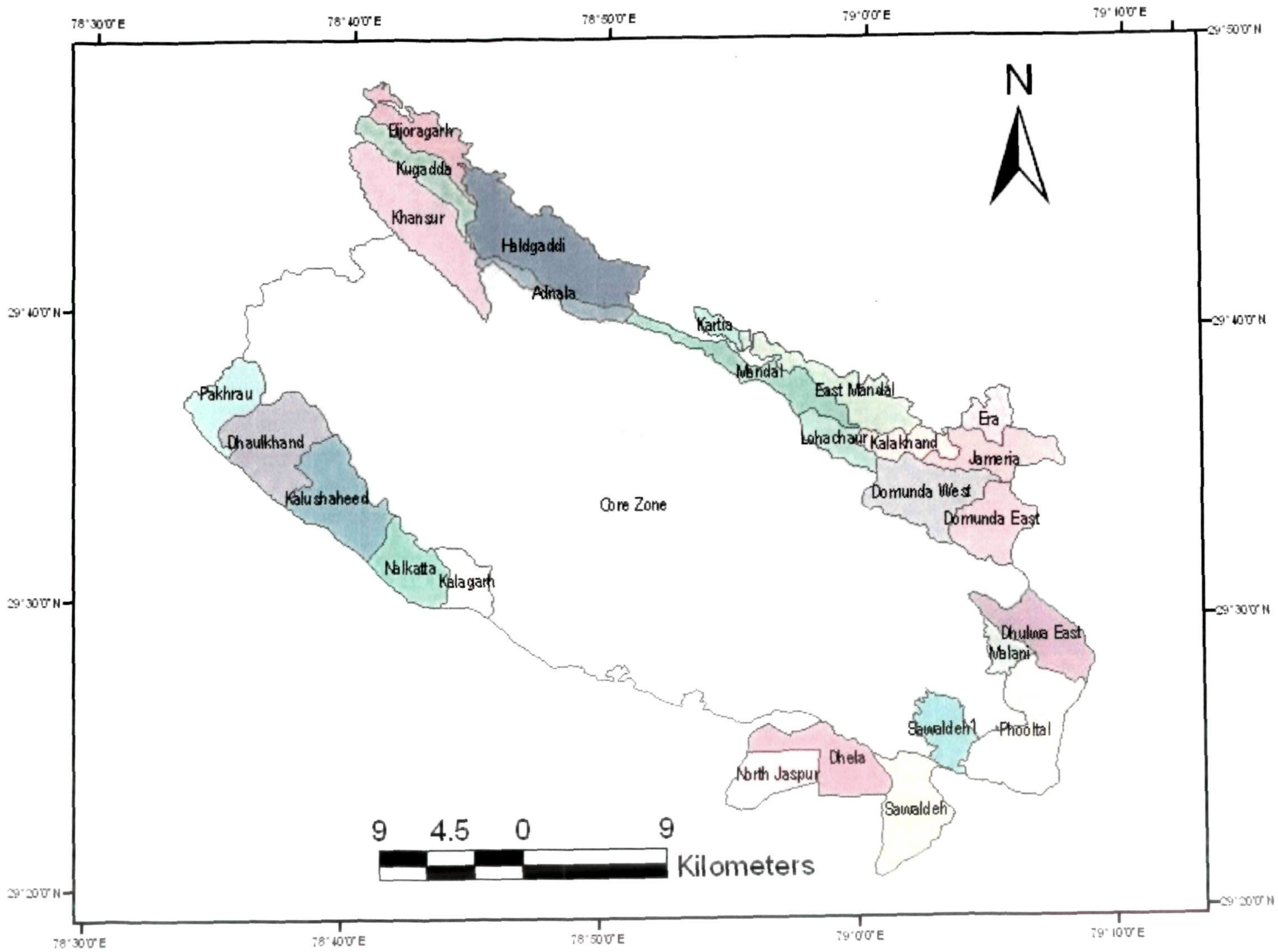
The terrain of the study area is hilly and undulating consisting of a number of ridges and valleys. Ramganga, Palain and Mandal rivers formed major river valleys in the study area. The extreme southern area, consisting of *bhabar* track, is relatively plain in nature. The altitude ranges from 350 m in southern part to 1210 m in the northeastern part of the CTR. Small streams cris-cross the entire study area, which join to form the major rivers in the area.



Map 4: Location map of the Corbett Tiger Reserve showing forest blocks



Map 5: Tourism zone and the Forest rest house in the CTR



Map 6: Map of Buffer Zone (Study area) showing forest blocks in the CTR

2.6 Geology

The geological formation of the area was divided into a) recent and b) Siwalik series. The recent geological formations included horizontal river gravels, alluvium and *bhabar* deposits (slightly old). The Siwalik series included upper Siwalik conglomerate, middle Siwalik sand rocks and lower Siwalik sand stone. The upper Siwalik conglomerate is semi-consolidated resembling gravel of *Bhabar* zone with large rounded quartzite pebbles set in ferruginous sand characterized by alteration of coarse and fine sand of sandy, loamy and clay beds. The middle Siwalik sand rocks consist of pure sand rock slightly ferruginous, at times felspathic with banded coloration, very soft always in state of rapid disintegration. The lower Siwalik sandstone is generally dark brown, traversed by numerous joints parallel and at right angles to the bedding place. On all southern aspects of Siwalik conglomerate, the soil is almost sandy and shallow. On 'dun' like flats the soil is deep, fresh though stony. Northern slopes have well drained sandy-to-sandy loam soil capable of supporting good forest.

2.7 Climate

The general climate of area is tropical with three distinct seasons i.e. summer, monsoon and winter (Bhartari 1999). June through September is monsoon, followed by a post monsoon season. November to March is winter season. This is followed by a summer season from April to mid-June. Rains ranging from 5 to 15 cm can usually be expected in January and February (Fig 2.2) and thunder showers often accompanied by hail are not uncommon throughout the hot months of April and May. The temperature drops to 2 ^{0}C in winter and rises to 45 ^{0}C during the hot season (Fig. 2.1). There is climatic gradient on a south to north and east to west axis.

2.8 Water sources

Ramganga, Mandal, Plain, and Kosi are the major perennial source of water in the study area. The Kosi River flowing on the eastern boundary is very important perennial source of water. Kosi does not enter the buffer zone of

CTR but is regularly visited by wild animals from the CTR. Phooltal is the only pond, which serves as a water source for the wild animals in buffer zone of the CTR. There are numerous small springs, which provide water not only to the wild animals but also to the villagers. There are numerous *nalas* and *sots*, but all are seasonal except Paterpani, laldhang, Kothiraw, Jhirna, Dhara, Garjia, and Kannojia sot.

2.9 Vegetation

Vegetation of study area is quite heterogeneous. Major portions of the buffer zone are covered by the Sal (*Shorea robusta*) along with its several associates. However there is wide variation in the species composition. Mostly species composition varies according to altitude. According to the forest classification of Champion and Seth (1968), following eight forest type are found in the Corbett Tiger Reserve.

(1) Sub-type 3C/C2a. Moist Siwalik Sal forest
(2) Sub-type 3C/C2b (1). Moist Bhabar Dun Sal Forest
(3) Sub-type 3C/C3a. Western Gangetic Moist mixed deciduous forest
(4) Sub-type 3C/1S1. Alluvial Savannah woodland forest
(5) Sub-type 5B/C1a. Dry Siwalik Sal forest
(6) Type 5B/C2. Northern Dry mixed deciduous forest
(7) Type5/1S2. Khair-Sissoo forest
(8) Sub-type 9/C1a. Lower or Siwalik Chir Pine Forest.

Since the recognition of above forest types requires in depth knowledge of species composition along with soil characteristics and rainfall pattern, therefore a simple classification of broad vegetation type was proposed for the purpose of present study, which can be easily recognized. Therefore, based on the structure, vegetation composition and topographic features seven major vegetation types were recognized in the study area.

a. Pure Sal: This vegetation type consists of particularly dense, pure population of Sal. These are good quality forest with low weed abundance and occur in patches all over the buffer except the western boundary of buffer zone of CTR.

b. Mixed: This vegetation type mainly consists of Sal and Rohini *Mallotus philippenensis* with their different associates. Common associates are Khuda *Ehretia acuminata,* Haldu *Adina cordifolia*, Kanju *Holoptelea integrifolia* and Dhuri *Lagerstroemia parviflora*.

c. Bakali mixed: This vegetation type mainly consists of Bakali *Anogeissus latifolia* with its associates. This vegetation type is found on the high slopes of hills in the study area.

d. Khair-Sisso: This vegetation type consists of Khair *Acacia catechu* and Sisso *Dalbergia sisso*. This type of vegetation is found on the periphery of buffer and adjoining areas. The areas covered by this vegetation are degraded to the high biotic pressure.

e. Riverine: Most of the island on the major rivers and water sources are covered with this vegetation type. This vegetation mainly consists of Jamun *Syzygium cumnni* and Sisoo *Dalbergia sissoo*.

f. Scrub: This vegetation type consist mainly the Ber *Zizyphus mauritiana* and grasslands. This type of vegetation developed in the areas, which are previously under human control. These areas developed after the relocation human habitations and cutting of plantations. These areas have high abundance of *lantana camara*.

g. Plantations: Along with the above vegetation types a considerable portion of study area is covered by plantations. These plantations are of Teak *Tectona grandis*, Eucalyptus *Eucalyptus hybrid,* Ailanthus *Ailanthus excelsa*, etc.

2.10 Human settlements

There are no revenue villages inside the core zone of CTR, except one Gujjar *dera*. The Gujjar is pastoral community. In the past, the Gujjar used to migrate to lower areas in winter and return to upper areas during summer season. But now they lead a permanently settled lifestyle in the lower areas. There are 140 revenue and forest villages (locally known as *Khattas*) including the *deras*, which are located in and around the buffer zone of the CTR. People of these villages are dependent on the buffer zone for grazing, fuelwood, fodder and other forest-based needs. Three villages, namely Dhara, Jhirna, Kothirau, located on the southern boundary of CTR were relocated outside in 1994 and relocation of the fourth village, Laldhang, is in the final stage of implementation.

2.11 Fauna

Mammals

A total 50 species of mammals are reported to found in the Corbett Tiger Reserve. But during the study period I have recorded 30 species of mammals. Among the large carnivores, tiger (*Panthera tigris*) was seen more frequently in comparison of leopard (*Panthera pardus*). However, both predator have good population in the study area but leopard have very healthy population in the northern portion of the Corbett Tiger reserve in comparison of rest of the area. Among the small carnivores jungle cat (*Felis chaus*), leopard cat (*Felis bengalensis*) and Jackal (*Canis aurous*) were also seen at few occasions on the southern portion of the CTR. An omnivorous, sloth bear (*Molursus urainus*) was also sighted in the miscellaneous forest on the outer hills. The small Indian civet (*Viverricula indica*) and yellow throated martin (*Martes flavigula*) was also seen during the study. Indian elephant (*Elephas maximus*) have wide distribution in the study area. Sometimes these elephant also raids the crops of local people.

CTR harbours seven species of ungulates. Among these chital is most common and found all over the CTR. Sambar and muntjac show some affinity to the hills and found more commonly in the hilly areas of study area. Hog deer found in the grassland areas and no sighting of species was recorded in buffer zone of the CTR. Nilgai was restricted to the southern portion of CTR and were regularly observed in Phooltal, Sanwaldeh Bhabar, Dhela buffer, N. Jaspur, Kalagadh and Nalkatta forest block of the study area. Goral and Serow found in very steep areas but I never encountered Serow during the study period.

Small mammals such as the Indian porcupine (*Hystrics indica*), common mangoose (*Herpestes edwarddsi*) and Blacknaped hare (*Lepus nigricollis*) were common and seen regularly in the area. In addition to this, smooth Indian otter was also an important mammal seen in Ramganga River. Along with this, troops of Hanuman langur (*Presbytis entellus*) and Rhesus macaque (*Macaca mulata*), ranging from few individuals to as large as fifty individuals, were sighted all over the CTR.

Birds

Corbett Tiger Reserve, because its location and diversity in the habitats is very rich in bird diversity and Zoological Survey of India have recorded over 585 species of resident and migratory birds in the area.

Pisces

The river Ramganga and Kosi sustains a large variety of fish. The Mahaseer (*Barbus tor*) is the main species found throughout the length of the river. The other species which could be mentioned are the Kalimuchi (*Barbus chilinoides*), Kalabasu (*Labco calabasu*), Chilwa (*Oxygastro bacaila*) and Goonch (*Bargarius bagarius*).

Reptiles

In the big pools of Ramganga and in small lake of Malani tal Indian Marsh Crocodiles or Magar (*Crocodilus palustris*) are found. Gharials (*Gavialis gangeticus*) are also seen in Ramganga River. As regards terrestrial reptiles, various species of snakes are found. Important species worthy of mention are King Cobra (*Naja bungarus*), Common Krait (*Bungarus *caorulcus*), Cobra (*Naja naja*), Russel viper (*Vipera ruselli*) and Python (*Python molorus*). Monitor lizard was also seen very frequently during the monsoon.

2.12 Management problems

1. Weeds

The common perennial weeds are *Lantana camera*, *Adhatoda vasica*, *Pogostron* and *Cannabis sativa* while *Partheniun hysterophorus* and *Casia tora* are annual weeds which reduce the suitability of the habitat for ungulates. *Lantana camera* is most problematic weed and covered large areas in open disturbed area. At places, *Lantana cover* is so thick that it does not allow anything else to grow and reduce the availability of fodder for ungulate species. But in spite of negative impact of *Lantana* on the forage availability to ungulates, it provides very good hiding cover for tigers. *Parthenium* is mostly found near human disturbed area. Forest department try to control the spread of these weeds by uprooting them every year.

2. Forest fire

During the summers the forest fire is common phenomenon in Corbett Tiger Reserve and control of it is most challenging job for the managers. As preventive measures, management burned dry leaf litter and vegetation near the roads and forest trails and control burning dry grasses in the selected area. In addition to this, to control the forest fire, forest fire line cleaned before the summer. But in spite of all the efforts of the forest department, there are incidences of fire on regular basis. Deciduous nature of vegetation coupled with drying up of annuals during summers allows accumulation of enough fuel on the forest floor and a little negligence on the part of people sparks of the fire.

Most of the forest fires are generated by the human beings. Sometime it takes place due to the negligibility of local people by throwing cigarette or *bidi* buds in forest but sometime it is intentional when pastoralists grazing cattle in the forest put on fires in order to get early palatable flush of grasses for their cattle. Control of forest fire in hilly areas is very difficult task for the forest department in comparison of forest fire in plain and valleys and is more devastating. Forest fires destroys ground flora and fauna more or less completely, enhances the chance of soil erosion, hampers recruitment of new forest crops and encourage spread of weeds like *Lantana*

3. Human interference

People living in and around the area go to the forest to graze cattle and to collect fuel-wood, fodder, thatching material and other NTFPs. All these activities have adverse effect on the quality of habitat available to wild animals. Grazing of livestock encourage spread of weeds and increase competition for fodder with ungulates.

4. Poaching

No incidence of poaching was recorded in the Corbett Tiger Reserve but sometimes there were news of poaching of ungulates in the adjoining forest areas of CTR. But forest department have to put immense effort to control poaching on the southern portion of study area. Southern portion connected with the Uttar Pradesh and have some community involved in the poaching of wild animals. To control the poaching, forest personals regularly patrol the area on foot and management also organize long distance patrolling on regular basis.

5. Wildlife-human conflict

Economy of local people living in and around the Corbett Tiger Reserve is primarily depending on the agriculture and cattle raring. Wild animals from the area raided crops of local people and killed cattle and sometimes humans and cause considerable loss to local people. Due to this locals have antagonistic view towards the managers of area and to tackle with this situation is most difficult job of forest department.

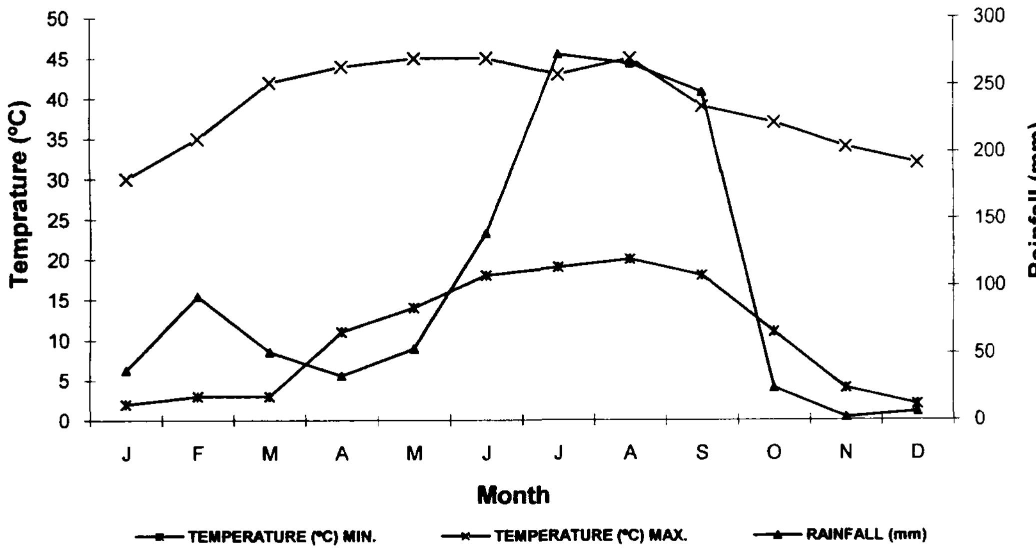


Figure 2.1: Mean monthly maximum and minimum temperature values and rainfall in the study area

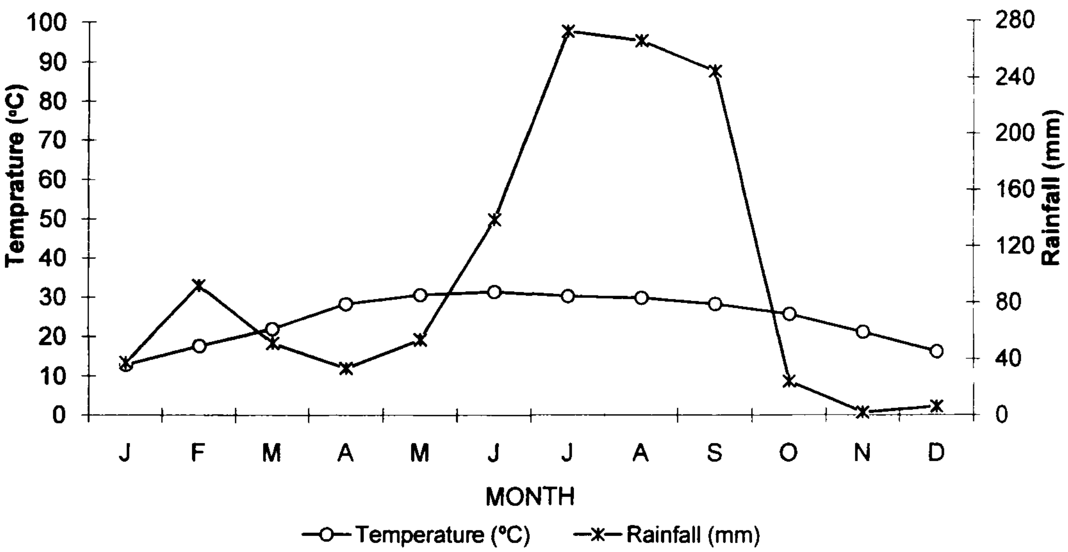


Figure 2.2: Average monthly temperature values and rainfall in the study area

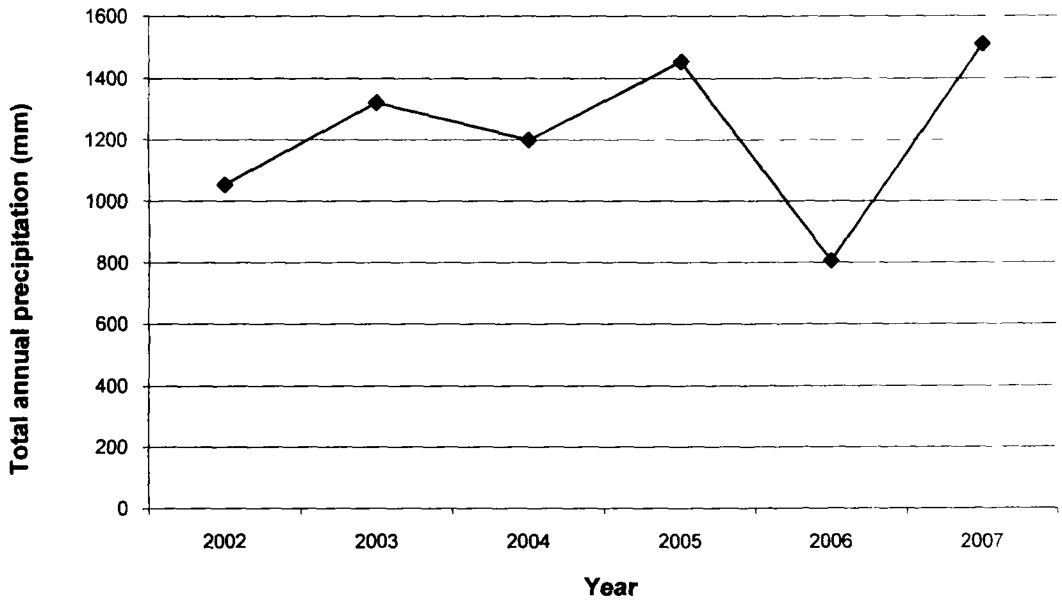


Figure 2.3: Annual precipitation in the study area (2002-2007)

3.1 Introduction

How many animals, is perhaps the most common question that biologists or reserve managers are asked and key to understand how tigers populations work (Karanth 2001). So the most important task of biologists is to determine the functioning and dynamics of populations of wild animals to ensure their sustainable management. Distributional range of tiger has shrunk 95% of its original range during the past century. Knowledge of distribution and abundance of species has implication for management and for tailoring management strategies. Abundance estimation or density of animal population is important for developing proper conservation policy and management protocols (Gelatt & Siniff 1999, Swann et al. 2002), particularly in case of threatened or endangered species like tiger.

Wild animals are rarely, if ever, distributed randomly across the landscapes. Rather, they space themselves in complex ways related to habitat type or condition, resource abundance and availability, and through intricate social interactions between conspecifics (Morrison et al. 1992, Williams et al. 2002). Spatial distribution can be defined as the occurrence and spacing of individually recognizable individuals within a defined area over a specified period of time, and requires an understanding of home range size, which varies with respect to each animal's gender and residency status (males typically occupy larger ranges than females, and permanent residents occupy more stable ranges than transient individuals) (Sunquist & Sunquist 2002).

Under the pressure of human activities habitats of wild animals change drastically and population of several species decreases to critical level. The conservation has now become a selective management of species unlike earlier thought of leaving the nature on its own to recuperate. It means for the conservation of wildlife, it is imperative to apply some management practice to make available better space for wild animals. To framing the management practices for the better management of tiger, it is prerequisite to have knowledge of status, distribution and abundance of tiger in different landscapes. Status of tiger is uncertain across its entire distributional range spanning 13 Asian countries (Karanth & Nichols 1998). Field surveys combined with forest cover maps have generated more accurate distributional maps but their utility for assessing the status and viability of tiger population is limited by the absence of reliable data on population densities (Karanth & Nichols 1998). Having sound and practical understanding of status and distribution of tiger population is critically important both for scientific and management purposes.

The secretive and elusive nature of tiger, along with dense habitat in which they live, make it difficult to study them. Historically, pugmark census has been used to determine the population status of tiger all over its range, but there were many limitations to this method and has been criticized by scientific community. Radio telemetry data can be used to derive estimates of tiger densities (Sunquist 1981, Smith et al. 1987a, b, Quigley 1993), however presence of untagged animals in the population and excessive effort involved in capture and radio tracking operations, limits the usefulness of this technique for estimating tiger population size (Karanth 1995). Therefore, recently developed technique of camera trapping is most appropriate and robust technique to determine densities of tiger and has effectively been used by several investigators (Pollock et al. 1990, Karanth 1995, Karanth & Nichols 1998, 2000, 2002, Kawanishi 2002, Karanth et al. 2004a, Per Wegge et al. 2004).

Most of the studies on abundance of tiger were conducted in core zone of protected areas, free from human disturbance (Karanth 1995, Karanth & Nichols 1998, Kawanishi 2002, Per Wegge et al. 2004). Information on abundance of tiger in disturbed habitats is still lacking. The objective of present chapter is to determine the status and abundance of tiger in buffer zone of the Corbett Tiger Reserve, subjected to human disturbances.

3.2 Methodology

To determine the density of tiger, advanced technique of camera trapping was employed following Karanth and Nichols (1998). In addition to this, tiger census data was also collected from the forest department.

3.2.1 Census data (Forest Department)

To determine the status and distribution of tiger in different forest blocks of buffer zone of the Corbett Tiger Reserve, block-wise census data for the year 1999, 2001, and 2003 were collected from the forest department. To delineate the blocks on the basis of abundance of tiger, block-wise tiger densities (number of individual tigers per 100 km^2) were calculated from the forest department data. Based on the density values, blocks were rated as having low tiger density (1-5 tigers/100 km^2), medium tiger density (>5–15 tigers/100 km^2) and high tiger density (>15 tigers/100 km^2). The tiger densities were plotted block-wise using software Arc GIS (version 8.3).

3.2.2 Camera trapping

Tigers naturally occur at low population densities and because of their secretive behavior, it is impossible to count them visually under usual field conditions (Karanth & Nichols 1998). Traditional monitoring of tiger population is the total count (census) of tigers through the identification of individual tigers by visual inspection of the pugmark tracings or plaster casts and mapping tiger distribution at the local scale (Choudhury 1970, Panwar 1979, Sawarkar 1987, Singh 1999). This methodology has received severe criticism since it depends on 1) subjective (Expert knowledge) identification of tigers based on their pugmark, 2) The pugmarks of tiger are likely to vary with substrate, tracing casts, and tiger gaits, 3) It is not possible to obtain pugmark of tigers from all tiger occupied landscapes and 4) Method attempts a total count of all tigers (Karanth et al. 2003). In view of above drawbacks of pugmark census, biologists proposed more rigorous technique of identification of tigers by camera traps in a capture-recapture statistical framework to determine tiger densities (Pollock et al. 1990, Karanth 1995, Karanth & Nichols 1998, 2000, 2002, Karanth et al. 2003, 2004a, Per Wegge et al. 2004). The method is appropriate to determine tiger densities in small areas having high to medium densities and has high potential for monitoring source population and smaller sample areas within tiger occupied landscapes (Jhala & Qureshi 2004) and is superior to every other method for estimating tiger abundance and density (Karanth & Nichols 1998).

Choice of camera equipments

Biologists mainly used two types of infrared camera trap units for density estimation. The 'active' type units have an infrared transmitter that emits a beam, which is received by an infrared receiver positioned opposite to it. When the tiger walks between the two units, the beam is interrupted and receiver activates the camera. While the 'passive' infrared camera units sense the heat emanating from the body of tiger passing in front of it. The receiver then completes the circuit and activates the camera.

In the view of merits and demerits of both units, I employed commercial active infrared camera units. Two trailmaster (USA) camera units were used for the photo trapping of tiger. Each unit consisted of TM35-1 camera kit (Canon A1/Prima AS-1; 35mm weather-proof, auto focus and auto find), TM 1550 infrared (IR) transmitter and TM 1550 active Infrared trail monitor (receiver) that activates the camera and records the date, time and event. During the study period I used the 36+ exposure 35 mm negative colour Kodak 400 speed and Fuji 400 speed camera rolls. I used especially designed wooden cages to mount camera. Wooden cages prevent the theft of camera and also protect camera unit from damage by wild animals.

Reconnaissance Survey

Since tiger occur at low densities of 10-20 animals/ 100km^2 even at the best sites, getting 'photographic capture' of a tiger is a rare, uncertain event (Karanth & Nichols 1998). So to maximize capture probabilities, it is imperative to select the best site for the placement of camera traps and should not be randomly placed. Before starting the sampling, a pilot survey of area of interest was done to have the basic idea of the movement and ranging pattern of tigers in the study area and to get familiarize with the area. During the reconnaissance survey of area, *nalas*, trails and forest roads were searched for the indirect evidences of tigers such as pugmark, scat, scrape and scratch mark. On the basis of these indirect evidences, potential trap locations were determined and were plotted on the map. Out of these locations, finally best suited locations were selected for the placement of camera units.

The assumptions of mark-recapture

There are two critical assumptions that should be meets during the camera trap studies-population closure and nonzero capture probability (*Karanth & Nichols 1998*).

Population closure: Capture-recapture is based on a closed population assumption. It means there is no birth, death, immigration or emigration within the study area during the study period. Since no tiger population is closed in the wild situation, so the study should be of short duration (Karanth and Nichols 1998). They also recommended that three is reasonable time frame to assume a closed population for the tiger.

Nonzero capture probability: Every individual inhabiting the area of interest has at least some probability of being captured i.e. photographed by the camera unit. Thus there should be at least one camera unit within its ranging area during the study period.

Designing the survey

Entire area of interest was divided into grids of 6.5 km^2 and each grid was selected as the unit for the placement of single camera trap unit. Within the grid the point having indirect evidence of tiger was selected for the placement of camera trap unit. Study area consisted of 24-unit grids to place the camera unit. To deal with space and time, Karanth and Nichols (1998) suggested four possible approaches to conduct the camera trapping studies.

1. If an adequate number of camera traps is available and if the study area is sufficiently small so that entire study area is covered in a single *sampling occasion, then traps can be spread throughout the area once* and then checked each day for say 5-30 consecutive days.

2. Frequently there will not be enough traps to sample the entire area of interest, but very frequent movement of camera traps to any potential trap site within the area may be logistically possible. In such situation, divide the area of interest into grid system. On first day, randomly select y "grid cells", where y corresponds to the number of available camera traps. Set the camera traps at sites having potential to capture tiger within each cell. On second day, randomly select y new cells, pick up camera traps and move them to potential sites within the new cells and set them. Repeat this procedure for 5-30 day.

3. If not only will the number of traps may not be adequate to sample the area of interest, but also the traps cannot be readily moved to any location within the study area. However, moderately frequent movement of traps will be logistically possible. Then divide the study area into trapping blocks and place the traps in block 1 for 1-5 days, then in block 2 for 1-5 days and do this until the entire study area covered. This entire set of days will be denoted as sample occasion 1. Then the procedure is repeated, and the resulting captures/recaptures will be assigned to capture occasion 2. The cycle is repeated until minimum of 5 "occasions" are obtained. Capture data are combined over all blocks for days 1-5 to define occasion.

4. If the number of traps is inadequate to sample the area of interest and frequent movement of traps is not logistically possible. Again divide the area in blocks and trap can be set out in the first block and left for 5-20 days. The traps are then shift to second block and left for the same number of days as block 1. The procedure is repeated until entire study area covered. The number of captures for occasion 1 is obtained as the total number of captures occurring on the first day of trapping in each block. The number of captures/recaptures for occasion 2 is obtained as the sum of captures/recaptures for the second capture day at each block, and so on.

Approaches 1 and 2 are more desirable in comparison of approaches 3 and 4 from the perspective of modeling and estimation. But due the shortage of camera units and logistic problem in frequent shifting of camera trap units, I applied last approaches for the camera trapping of tiger in the study area. I placed camera traps for 10 days in a grid and then shifted them to the next grid.

Programming of unit

Receiver was programmed to register event and triggered the camera unit when the infrared beam is interrupted for the 0.25 second (-P 5) since the body of tiger is enough to interrupt 5 pulse of beam. It prevents the wastage of film roll from other non-target animals as small animals or falling leaves. All camera trap units were programmed with a delay between successive photographs and I selected smallest value available 0.1 minutes (times available 0.1 minute to 98 minutes) so that if tiger cubs accompany, they should not be missed. The time, receiver allow camera activation was 17:00 to 08:00 in winter and 18:00 to 07:00 in summer.

Before the set up of the camera trap units, all the units were labeled with unique identification number. A unique number was also provided to every film roll before it was loaded in the camera to know the location of photographs of tiger captured during the study.

Set up of camera trap

After the selection of potential trap site, camera units were framed in such a way so that tiger's both flanks would get photographed clearly. Camera traps were mounted on locally designed wooden posts 7 m or sometimes >7 m away, on either side of the tiger trail or path. To avoid flaring of photo from mutual flash interference, two cameras were not positioned directly facing each other. Infrared beam was set at a height of 45 cm above the ground so that camera units would able to capture both adults and cubs. Cables connecting the whole unit were hidden in the soil and leaf litter but during the summer, soil was preferred to hide the cables since in case of forest fire litter would help in damage of unit through fire. After the set up of camera trap, units were concealed with the branches of trees.

Camera trapping was carried out in the buffer zone, which during day time have human activities. Local people go into the forest for the collection of fuelwood, fodder and NTFPs (Non timber forest products) and grazing of livestock. So to avoid theft and damage by local people, camera units were set up in the evening and were taken out in the morning.

Statistical framework

Understanding of how many tigers are in a protected area and how these numbers change over time is fundamental key for the conservation and management of it (Per Wegge et al. 2004). In camera trapping, based on capture-recapture theory, capture history for each individual tiger captured during the survey was developed. The capture history for individual tiger is in the form of a matrix, having the individually identified tiger making up the rows and different sampling occasions making up the columns of the matrix. The capture histories are in the form of series of 1's or 0's, denoting capture with "1" and non-capture with a "0". Capture histories were developed for all adult tiger captured during the camera trap survey. These matrices were then utilized for the estimation of abundance of tiger. After the preparation of matrices, capture probabilities were estimated using the model that best fitted these capture history data (Otis et al. 1978, Nichols 1992, Thompson et al. 1998). The population size of tiger in the sampled area then calculated using capture history data in conjunction with selected model.

The capture history data were analyzed using program CAPTURE (Otis et al. 1978, White et al. 1982, Rexstad & Burnham 1991). This program computes abundance under seven models that differ in their assumed source of variation in the capture probability. The details about these models are provided somewhere else (Karanth and Nichols 1998, 2002). Karanth and Nichols (1998) define (p.sub.ij) as the probability that individual i is captured on occasion j.

Within program CAPTURE there are 3 sources of variation affecting capture probability: time variation (M_t), behavior variation (trap-response) (M_b), and heterogeneity variation (M_h). There are also combinations of all three sources of variation (e.g. M_{tb}, M_{th}, M_{bh}, and M_{tbh}). Individual heterogeneity means variation in capture probability among different individual, such that each and every tiger is thought to have its own capture probability, which differ from the capture probability of all other individual tigers. Behavioral responses refer to changes in capture probability that occur due to change in the response of tiger to the presence of camera trap after an individual is caught for the first time. It means, at any sampling occasion j, unmarked individual have one capture probability and previously marked animals have a different capture probability. Time variation deals with variation in capture probability from one sampling occasion to another.

Program CAPTURE computes number of individuals in the study area and associated standard error of abundance. From this estimate of tiger abundance, density of tiger in the sampled area was calculated. Density of tiger is described as D = N/A where, N is number of individuals, and A is the area in which the individuals roamed. Since during the camera trapping sampling, only a small portion of tiger habitat available was sampled and it is necessary to calculate effective area from which animals sampled. The effective sampled area encompasses the camera traps polygon with a buffer around the peripheral camera traps that takes into account those individuals whose home range may include areas that are only partially contained within the sampling area. There are numerous approaches to calculate this buffer. Karanth and Nichols (2002) used a buffer whose width was based upon half the mean maximum distance moved (HMMDM) among multiple captures of individuals during the study period. According to Dice (1938) buffer width is half of the average diameter of home range of the species. Spacing of camera traps in survey area affects the home-range size estimated based on capture data (Stickel 1954), but the effect is reduced for animals caught 6 or more times (Tanaka 1980). Since no tiger was captured more than twice during the survey period, buffer width estimation based on recapture data would have been biased. Therefore value of half of the mean maximum distance moved (MMDM) in Kanha (2.17 km) was used by Karanth and Nichols (1998) was used to calculate effective sample area. Geographical Information System (GIS) was used to create the buffer around the peripheral camera units and to estimate effective sampled area (Map 7).

In addition to an estimated abundance, programme CAPTURE also generated a capture probability, a standard error of the abundance estimate and a 95% confidence interval. This method is not designed to give an absolute number, but to give a statistically robust estimate of the abundance range. The standard error and confidence interval provide measures of uncertainty with the abundance and are thus important in determining how the estimate is interpreted.

3.3 Results

3.3.1Block-wise abundance of tiger (Forest department data)

Forest department reported 44, 47 and 58 tigers in the buffer zone of the Corbett Tiger Reserve during 1999, 2001 and 2003 census, respectively. The calculated average density of tiger in buffer was 9 tigers/100 km^2, 10 tiger/ 100 km^2 and 12 tigers/ 100 km^2 during 1999, 2001, and 2003, respectively. Table 3.1 shows the trends in tiger abundance in the buffer zone of the Corbett Tiger Reserve from 1999 to 2003. The number of blocks with, no tigers as well as, with low abundance of tigers, decreased between the years 1999 to 2003. Forest blocks with medium abundance of tigers had initially come down in 2001 and then increased by 2003. Although in 1999 only one forest block of the buffer zone had high abundance of tigers, by 2001 there were 2 forest blocks with high abundance. The census data of 2003 also identifies only 2 blocks with high tiger abundance.

Apart from changes in the number of blocks under different density categories, there were changes observed even in the spatial distribution of these categories. Maps 8 and 9 based on the forest department data for the years 2001 and 2003 respectively, show relative abundance of tigers in different blocks of buffer zone of CTR. While in the northwest there was an improvement from 2001 to 2003, in the northeast, some of the blocks, which were under high or medium tiger density (2001), showed lower tiger densities according to 2003 census (Appendix I). The density of tigers in the forest blocks in the southern portion of the buffer zone also showed improvement in 2003 compared to 2001 (Table 3.2 and Appendices I and II). A comparison of three censuses viz. a. viz. different zones of the CTR showed that the blocks in south and south east accounted for 36.5%, 43.5% and 44.7% of tiger population alone in year 1999, 2001 and 2003. The North West and south west had the lowest numbers of tigers recorded in three censuses.

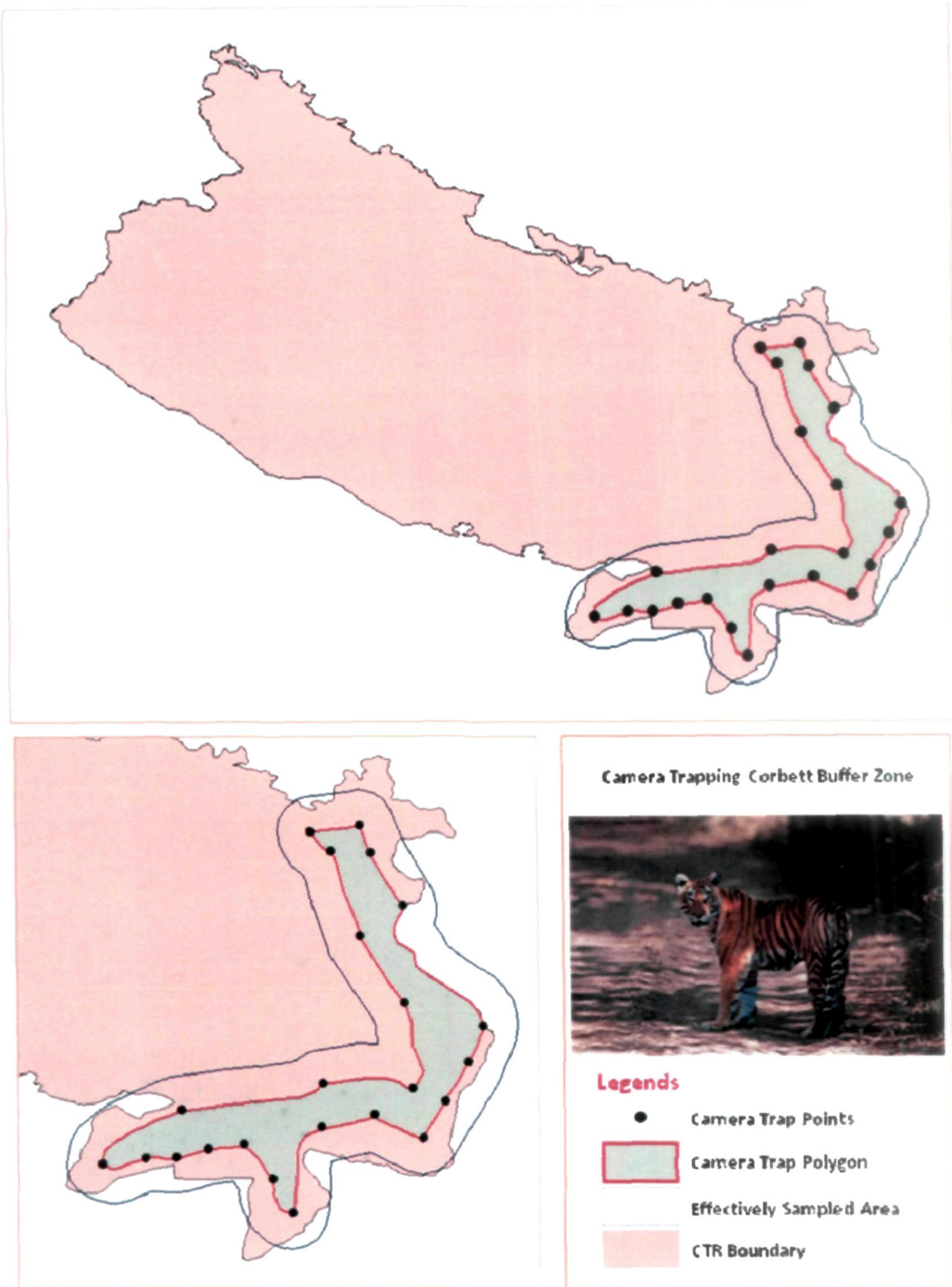
Table 3.1: Block-wise abundance of tigers in buffer zone of the Corbett Tiger Reserve

Year	Nil (%)	Low (%)	Medium (%)	High (%)
1999	9 (34.6)	5 (19.2)	11 (42.3)	1 (3.9)
2001	9 (34.6)	7 (26.9)	8 (30.8)	2 (7.7)
2003	7 (26.1)	2 (7.7)	15 (57.7)	2 (7.7)

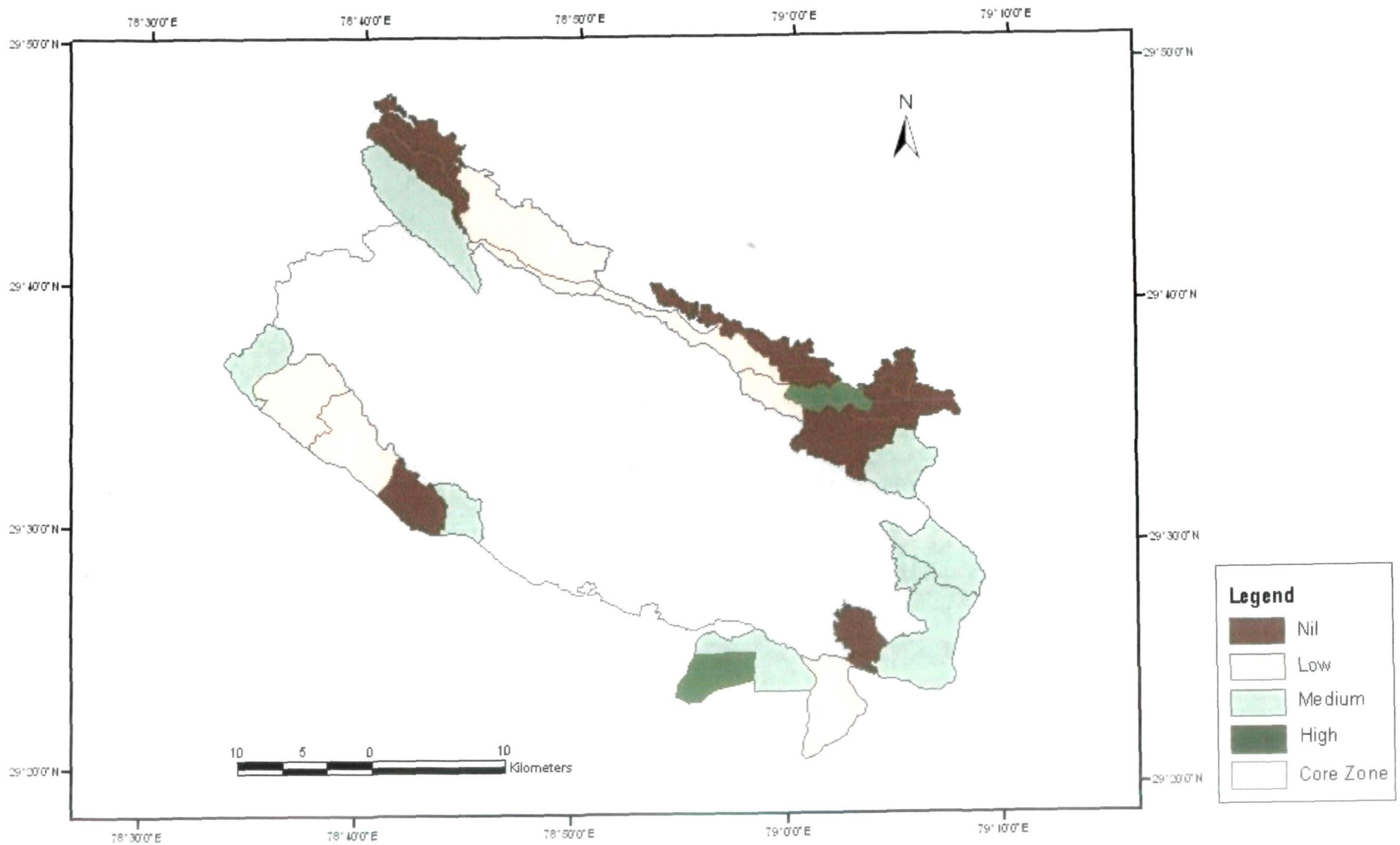
Source: Forest Department census data

Table 3.2: Block area under different categories of tiger density in two different years in the buffer zone of Corbett Tiger Reserve (Hectares)

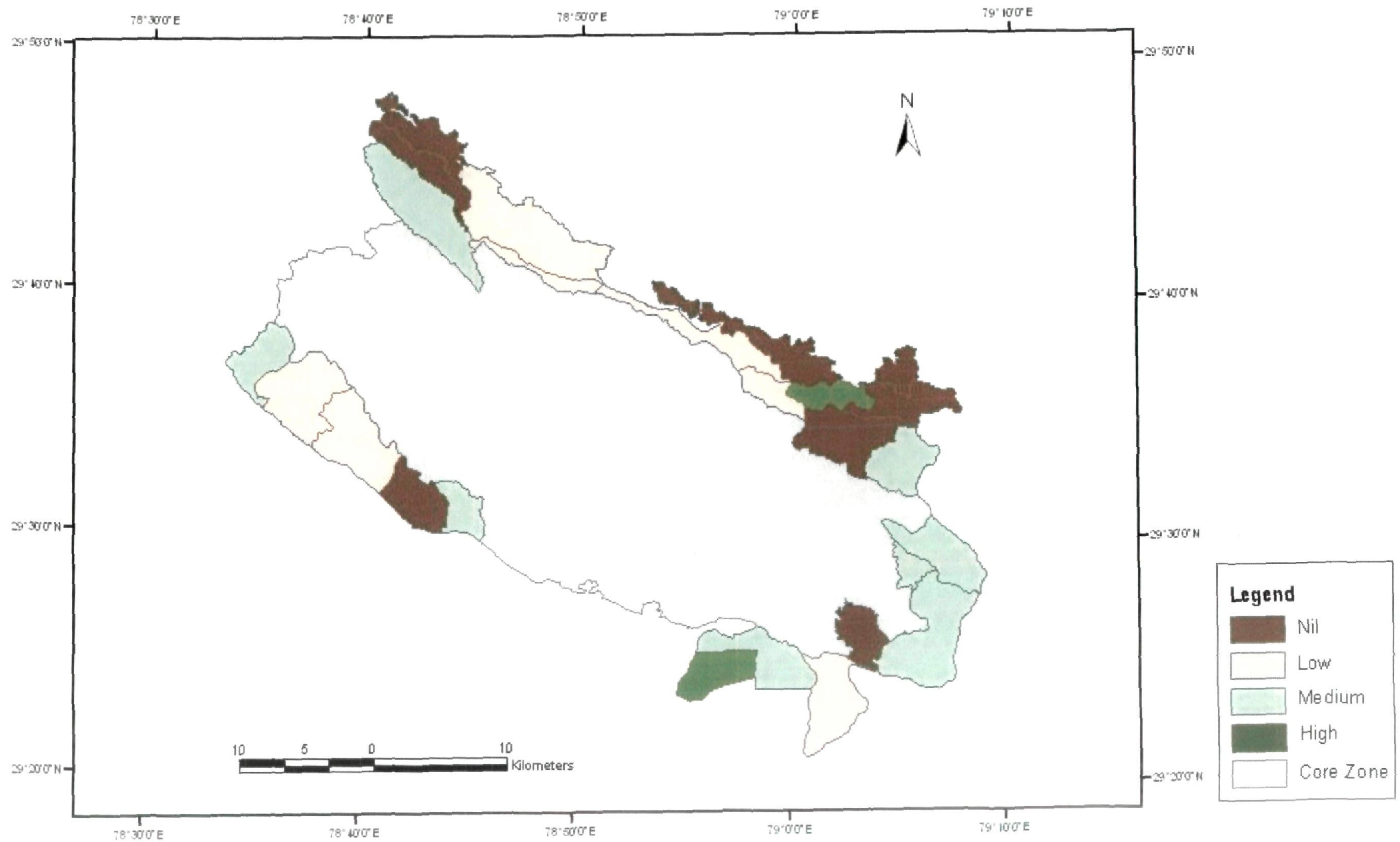
Year	Nil	Low	Medium	High
2001	**12636.3**	**16361.7**	**15522**	**2237.8**
2003	**8180.8**	**3392.6**	**32476.3**	**2708.1**



Map 7: Map of Corbett Tiger Reserve showing layout of camera trap with effective sampled area



Map 8: Spatial distribution of tiger density in different blocks of the buffer zone of the CTR in 2001



Map 9: Spatial distribution of tiger density in different blocks of the buffer zone of the CTR in 2003

The abundance of tiger in 46 blocks (including core zone also) showed positive correlation with chital (r_s = 0.37, N = 46, P<0.01), sambar (r_s = 0.40, N = 46, P<0.01), hog deer (r_s = 0.37, N = 46, P<0.01), nilgai (r_s = 0.40, N = 46, P<0.01) and wild pig (r_s = 0.37, N = 46, P<0.01). However tiger abundance did not show any significant correlation with different ungulate species except wild pig (r_s = 0.60, N = 11, P<0.05) when only 11 blocks (intensive study area) of south and south east zone of buffer zone is taken into consideration.

6.3.2 Camera trapping

Sampling efforts

Table 3.3 provided summarized result of camera trap survey. The total sampling efforts were amounted 240 trap-nights and spread over a period of 5 months. During the survey period, 32 rolls of 36-exposure film were expended to obtain 24 photographic captures of tigers (Fig. 3.1). The average trapping effort was 10 trap nights per capture and the quantity of film expended was about 48 frames per capture.

Table 3.3: Summarized results of camera trap survey in the buffer zone of the Corbett Tiger Reserve

Total number of camera trap locations	24 trap locations
Sampling effort	240 trap nights
Number of sampling occasions	10
Camera trap polygon area	109.07 km^2
Effectively sampled area	321.54 km^2
Number of individually identified tigers	20
Capture-recapture model selected to estimate population size	M_h
Estimated animal density for tigers in the sampled area	13.68 tigers/ 100 km^2

Identification of individual tigers

Most of the photographs captured were of high quality and were useful for distinguishing tigers unambiguously, except in two captures when in one case a tiger came very close to trap and the camera could only recorded the face of that tiger while in the other case the tiger moved very fast and one camera could photographed back portion of a tiger due to delay in cameras functioning to avoid flaring of photo from mutual flash interference. The stripe patterns are asymmetrical on two flanks of the same animal (Fig. 3.2). In addition to stripe pattern, pattern on tail, genital organs and other unique pattern were also taken into consideration to identifying the individual tigers. Twenty four tiger captures recorded in survey helped to identify 20 individual tigers in survey area.

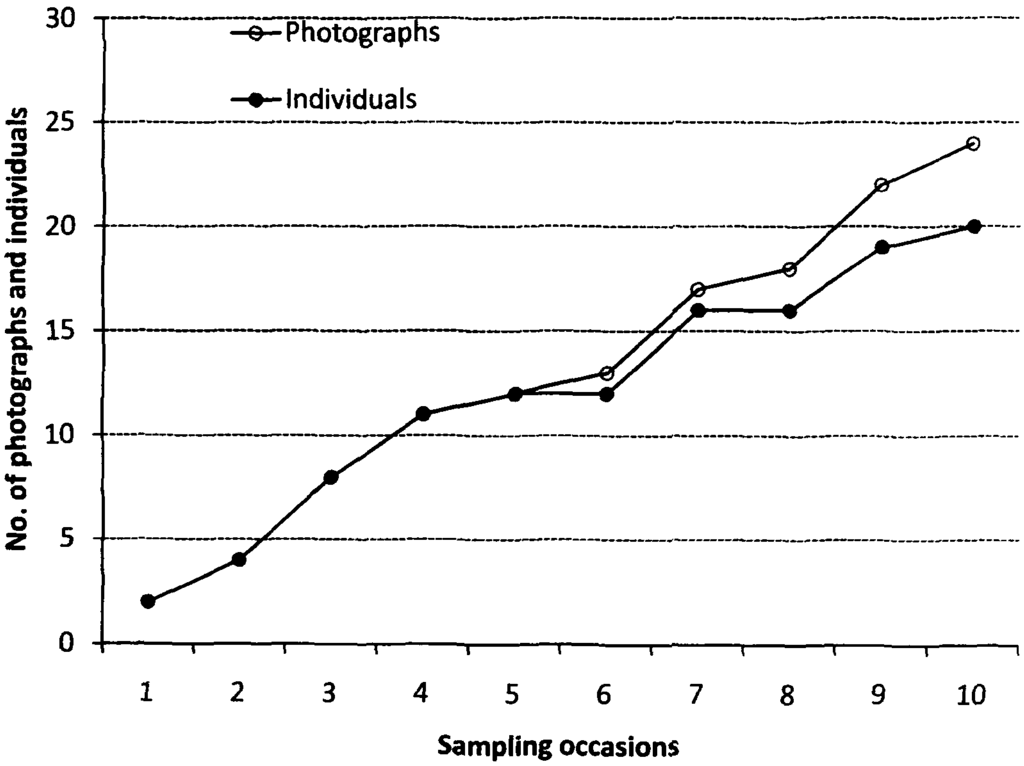


Figure 3.1: Commulative number of tiger photographs indicating number of individual tigers captured with increasing sampling occasions

Capture histories and sample statistics

Capture histories of 20 individually identified tigers which utilized the study area are provided in table 3.4 and summarized capture statistics (Otis et al. 1978) is provided in table 3.5. Computation of capture frequencies indicated that four individual tigers were captured twice and rest (16) of the individual tigers was caught only once. The assumption of closed population or null hypothesis could not be rejected ($z=0.075$, $p=0.53$). Closed-capture models should ideally not be used to calculate the abundance of small (<20) population (White et al. 1982), but survey area had a larger population than recommended.

Model selection

The hypothesis that the above capture-recapture statistics came from an underlying model M_0 could not be rejected in contrast to the alternative hypothesis of the underlying models, respectively M_b (χ^2 = 0.409, d. f. =1, p= 0.52) or M_t (χ^2 = 6.447, d. f. = 9, p = 0.69). Test comparing, model M_0 versus M_h and model M_t versus not model M_t, could not be conducted because expected values were too small. Goodness-of-fit test comparing null hypothesis of model M_h versus not model M_h, and M_b versus not model M_b failed to reject the null hypothesis (χ^2 = 6.231, d. f. = 9, p= 0.72), (χ^2 = 12.282, d. f. =15, p = 0.65), respectively. Similarly, test for behavioral responses in presence of heterogeneity also failed to reject the null hypothesis of model M_h versus alternative hypothesis of model M_{bh} (χ^2 = 9.938, d. f. = 7, p = 0.19).

The model selection criteria value computed for different models were; M_0 = 1.00, M_h = 0.80, M_b = 0.35, M_{bh} = 0.63, M_t = 0.00, M_{th} = 0.32, M_{tb} = 0.31, M_{tbh} = 0.70. Although the null model (M_0), based on criterion selection value, appears to be most appropriate for the data base, but White et al. (1982) cautions against its use in case when sample size are too small or individual heterogeneity and trap response may be present. Since tiger is territorial animal (Sunquist 1981, Smith et al. 1987a), therefore capture probabilities were likely to be heterogeneous for tigers in the surveyed area. Therefore, I selected model M_h, which had the second highest selection criterion value and was most appropriate model in this case. Program CAPTURE provided two different estimations for M_h

model; the Jackknife estimator (Otis et al. 1978) and Chao estimator (Chao 1987).

Table 3.4: Capture histories of individually identified tigers in buffer zone of the Corbett Tiger Reserve

ID. No.	Location	Capture
CTR 1	Laldhang	1 0 0 0 0 0 0 0
CTR 2	Laldhang	0 0 1 0 0 0 0 0
CTR 3	Laldhang	0 0 0 1 0 0 0 0
CTR 4	Dhela near Gujjar settlement	0 0 1 0 0 0 0 0
CTR 5	Sanwaldeh bhabar	1 0 0 0 0 0 0 0
CTR 6	Dhela near Jims Jungle Retreat	0 0 0 0 1 0 0 1
CTR 7	Seldhari sot	0 0 0 1 0 0 0 0
CTR 8	Seldhari sot	0 0 0 1 0 0 0 0
CTR 9	Teenpani sot	0 1 0 0 0 1 0 0
CTR 10	Mohan near range office	0 0 1 0 0 0 0 0
CTR 11	Kulvant sot	0 0 1 0 0 0 0 0
CTR 12	Chimtakhal	0 1 0 0 0 0 0 0
CTR 13	Chimtakhal	0 0 0 0 0 0 1 0
CTR 14	Domunda 100 FT	0 0 0 0 0 0 0 0
CTR 15	Mohan near range office	0 0 0 0 0 0 0 0
CTR 16	Teenpani sot	0 0 0 0 0 0 0 0
CTR 17	Aamdanda	0 0 0 0 0 0 1 0
CTR 18	Aamdanda	0 0 0 0 0 0 0 0
CTR 19	Near Sikarikuan	0 0 0 0 0 0 1 0
CTR 20	Pattharkuan	0 0 0 0 0 0 1 0

1, capture; 0, no capture. The ten sequential positions of these notations represents the successive sampling occasion during survey period.

Table 3.5: Summary of capture-recapture statistics for tigers obtained from camera trap sampling in the buffer zone of the Corbett Tiger Reserve

	Sampling occasion (j)									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Animal caught (n_j)	2	2	4	3	1	1	4	1	4	2
Total caught (m_j)	0	2	4	8	11	12	12	16	16	19
Newly caught (μ_j)	2	2	4	3	1	0	4	0	3	1

n_j, no. of animals captured on the *j*th sampling occasion.

m_j, no of previously caught animals before the *j*th sampling occasion.

μ_j, no. of new animals captured in the *j*th sample.

Figure 3.2: Example of asymmetry of stripe pattern on two flanks of the same animal

Tiger population in buffer zone of the Corbett Tiger Reserve

The estimated population together with the standard error and 95% confidence interval and average capture probabilities (p) derived using model M_0, M_h (Jackknife), and M_h (Chao) are provided in table 3.6. It can be seen that M_h (Jackknife) model provided most appropriate estimation of tiger population (N) with lower standard error and therefore this model is likely to include true value of 'N'.

Thus estimated population size *N* (SE [*N*]) was 44(10.69). The 95% confidence interval estimated by estimator M_h (Jackknife) as 31-75, is narrower than the interval, 29-135, generated by M_h (Chao) estimator.

Table 3.6: Estimates of population size (*N*) together with average capture probability (*p*), standard error (*SE*) of N and 95% confidence intervals (N_{ci}) for the tiger population in buffer zone of the Corbett Tiger Reserve during survey period

Model used	*P*	*N*	SE	N_{ci}
***M_0* (Null)**	0.043	55	23.05	32-133
***M_h* (Jackknife)**	0.054	44	10.69	31-075
***M_h* (Chao)**	0.046	55	23.32	29-135

The area of trap polygon (*A*) formed by using location of peripheral camera traps was measured to be 109.07 km^2. Since peripheral camera traps also have the probability to capture those individuals whose home range may be partially within sampled area, therefore effective sampled area was calculated. With a boundary strip width (*W*) of 2.17 km, effective sampled area *A* (*W*) was calculated 321.54 km^2. Therefore, the estimated tiger density D (SE [*D*]) for sampled area of the buffer zone of the CTR is 13.68 (3.32) per 100 km^2.

During the survey period it was found that, no tiger cub was captured in any of the camera traps. The capture probabilities for small cubs might have been very poor or even zero and to estimate abundance of tiger cubs, separate estimates based on number and reproductive status of resident females are required which I could not get, as is suggested by Karanth (1995).

3.4 Conclusion and discussion

Knowledge of abundance of tiger is imperative to tailor better management strategies to ensure continous survival of tiger. The mangement strategies should be based on sound estimates of abundance of tiger in scientific framework. Camera trap capture-recapture survey of tiger can yield robust estimates of tiger at sites where tiger densities are 3 tigers/ 100 km^2 or higher (Karanth & Nichols 2000). Estimates of tiger abundance, support earlier findings (Karanth & Nichols 1998, Karanth et al. 2004a) that photographic capture-recapture sampling is a reliable technique for estimating the abundance of tiger and other secretive animals that can be identified individually on the basis of their natural markings.

3.4.1 Forest Department data

Comparasion of tiger densities in the buffer zone of the CTR, during 1999, 2001 and 2003 (census conducted by forest department), indicated increasing trend in tiger density. It means tiger population is under better management inputs practised by the management of the Corbett Tiger Reserve for the conservation of tigers and its prey. The change in number of blocks having nil, low, medium or high tiger density categories could be a matter of chance. Tiger is a large predator having large home range and it would take several days to cover the entire home range . Therfore, it is just matter of chance of occurrence of tiger in particular forest block on particular day of census.

On consideration of overall spatial distribution in different forest block of buffer zone, it was found that most of the blocks with no tiger were located in north and northeastern part of the study area, except the Nalkatta forest block located in south-western part. The north and north-eastern part is highly hilly in terrain and could be one of the factors behind the absence of tiger in these blocks. Moreover, all these blocks had low or nil abundance of chital and sambar, the principal prey species of tiger, and overall availabilty of tiger prey biomass (Chapter 6). However, absence of tiger from Nalkatta was not explicable. One reason could be that, although tigers were present in this block and during census operation, ground level field staff also collected pugmark tracing and plaster castes. But in case of presence of same individual in adjoining forest block, at the time of identification of individual tigers, tracing and plaster cast from Nalkatta block might be discarded due to duplication with tracing and plaster cast from adjoining forest block. Another reason might be that, during census operation tigers using Nalkatta block *might be presnt in adjoining block since they have large* range.

Results of forest department data indicated that blocks located in southern and south eastern part of buffer zone, had supported major portion of tiger population present in the buffer zone. This is because, these areas are plain and had high density of prey species, therefore support major part of the tiger population present in buffer zone of the Corbett Tiger Reserve.

Abundance of tiger was found to be positively correlated with density of prey species, in case when compared for entire Corbett Tiger Reserve (including forest blocks of core zone). Whereas, did not show any correlation, except positive correlation with wild pig density, in case when compared for 11 forest blocks (intensive study area) located in south and south-eastern parts of the study area. Tiger abundance is influenced by distribution and abundance of prey species (Karanth & Sunquist 1995, Miquelle et al. 1996, Karanth & Nichols 1998), therefore abundance of tiger was positively correlated with abundance of prey species. Absence of positive correlation between tiger and prey abundance (in buffer) might be because of under the influence of human disturbance in buffer zone. Moreover, livestock species also served as significant prey for tigers in south and south east part of study area. Since livestock species were not included in analysis of correlation, it might affect the results.

3.4.2 Camera trapping

To identify individual tigers, different recognizable section on individual tigers were used. Since, tigers were not always captured at the same angle to the camera, therefore a specific pattern of stripe could have been obscured in a particular photograph, making identification difficult if only one region of the body was used for identification. The use of different distingushing features proved to be useful technique to confirm the identity of a particular tiger.

The assumption of population closure used in estimation of tiger densities may be a limitation of camera trapping technique. Closed population models, most robust model to estimate population size of animals, assume that animals are not moving out of the area and there are no birth or death i.e. the population remains constant in size and composition throughout the survey period (White et al. 1982). It is difficult, if not possible to acertain closure of biological population in wild (Soisalo & Cavalcanti 2006) since birth or death of individuals or takenover of territory by transient individuals may cause violation of assumption. Small recaptures of tiger is because of availability of only two camera trap units. It could have been possible to get more recaptures with more camera trap units and in turn would have produced more robust estimation of population size of tiger in the study area. Low sample size is also a natural consequence of studying difficult-to-detect, low density animals (Kawanishi 2002).

Model M_h, which assumes that capture probabilities vary with heterogeneity effect among individuals, but the probability of each individual being recaptured remains same throughout the sample period, was selected, although model selection criterion value was found to be lower than null model M_0. Due to social structure and unequal access to camera traps, there was heterogeneity effect on capture probabilities of different tigers, therefore model M_h provided reliable estimates of population size. Moreover, the robustness of the Jackknife M_h estimator to deviation from model assumptions (Otis et al. 1978) made it more appropriate. In several tiger camera trapping studies (Karanth 1995, Karanth & Nichols 1998, Karanth et al. 2001, Kawanishi 2002, Kawanishi & Sunquist 2004), model M_h was selected to estimate population size of tiger in different parts of its range. Model M_h assumes that each individual animal has a unique capture probability that is not affected by animals response to trap or time. There is no violation of assumption since camera trapping is a non-invasive technique. Moveover study was conducted in the buffer zone, with presence of human disturbance, tigers were already habituated to occurrence of negligible disturbance of the camera traps.

The comparison of tiger density derived from forest department data (12 tigers/100 km^2) is quite comparable with density estimated by capture-recapture technique (14 tigers/100 km^2). The high density of tiger in study area indicated that buffer zone had potential to support high density of tiger and play important role in long term conservation of tiger in Corbett Tiger Reserve. Inspite of biotic pressure from local people in terms of grazing, cutting and lopping, buffer zone has potential to support the high density of tiger and need proper habitat management to meet the needs of tiger.

Comparing the estimate of tiger density with various protected areas (Table 3.7), it is evident that buffer zone of the CTR has highest tiger density. The probabilty behind the high density in the buffer zone may be because, it may be acting as a sink to the source populations from the core zone. Study conducted by Contractor (2007) revealed that core zone of the Corbett Tiger Reserve has the highest tiger density (20.79 tigers per 100 km^2) in the world. If that is the case, then my findings of the buffer zone density is in accordance to my conclusion that buffer zone acts as the sink to the source population which is the core zone of the CTR. Further more, this buffer population acts as a source population to the nearby reserve forests. The conservation of the buffer zone is therefore, vital for the conservation of tiger and the CTR, because it maintains the flow of the gene pool to the neighboring areas.

Table 3.7: Comaprison of tiger denity with different protected areas

Location	Forest type	Tiger Density (Per 100 km^{-2})	Source
Pench (MP)	Moist-deciduous forest	04.9	Karanth & Nichols (2000)
Kanha	Moist-deciduous forest	11.7	Karanth & Nichols (2000)
Kaziranga	Alluvial grassland forest	16.8	Karanth & Nichols (2000)
Nagarahole	Moist forest	11.9	Karanth & Nichols (2000)
Bhadra	Moist forest	03.4	Karanth & Nichols (2000)
Bandipur	Moist-deciduous forest	11.9	Karanth & Nichols (2000)
Ranthambore	Dry Forest	08.2	Karanth & Nichols (2000)
Sundarbans	Mangrove Forest	0.84	Karanth & Nichols (2000)
Panna	Dry Forest	6.94	Karanth et al. (2004a)
Chilla Range of Rajaji	Moist-deciduous forest	3.01	Harihar et al. (2006)
Corbett (Core)	Moist-deciduous forest	20.79	Contractor (2007)
Corbett (BZ)	Moist-deciduous forest	13.7	Present Study

My study area, the buffer zone of the CTR, is subjected to adverse anthropogenic pressure of forest fires, livestock grazing, lopping and cutting by local people. Wild prey species of tiger were abundant at 58 individulals/km^2. The mean density of tiger at survey area (13.68) is higher than at other moist-deciduous forest sites at Pench (4.9 tigers/ 100 km^2), Kanha (11.7 tigers/100 km^2) and Bandipur (11.9 tigers/100 km^2). Moveover, estimated density is quite high than the Chilla range of Rajaji National Park (3.01 tigers/ 100 km^2).

Tiger requires annually an average 3000 kg of live prey/tiger (Sunquist 1981) and tiger take about 10% of the standing prey numbers each year (Karanth et al. 2004a). Calculated tiger density 14 tiger/100km^2 is close to predicted based on the prey abundance equation (11 tigers/100 km^2) given by Karanth et al (2004b). This could be because, in the study area (buffer zone) livestock also serves as a potential prey base for the tiger but at time of prediction it was not included in prey abundance. Therefoer availabilty of livestock as potential prey in buffer increased its potential to high density of tiger in comparision of predicted on the basis of abunadance of natural prey species.

4.1 Introduction

Carnivore-human conflicts pose an urgent challenge worldwide because these conflicts often put human communities against carnivores and those who seek to preserve or restore their populations (Torres et al. 1996, Bangs et al. 1998, Berg 1998, Karanth & Madusudan 2002, Treves & Karanth 2003, Loe & Roskaft 2004). Large carnivores are always considered a threat to human beings (Brantingham 1998, Treves & Naughton-Treves 1999) and problem of large carnivore-human conflict have historically occurred wherever wild predators have co-existed with humans (Davenport 1953, Schaefer et al. 1981, Bibikov 1982, Boitani 1982, Kaczensky 1996, Sekhar 1998, Vijayan & Pati 2002, Madhusudan 2003, Mishra et al. 2003). Livestock attacks by large carnivores and retaliatory killings by humans has persisted for centuries (Boitani 1995) and is a major reason behind extirpating them in parts of their range or reducing them to small rampant populations (Servheen 1990, Promberger & Schroder 1993).

Under a variety of demographic, economic, and social pressures, human alteration of carnivore habitats or exploitation of carnivores has led to escalated conflicts (Mlandenoff et al. 1997, Liu et al. 2001, Treves & Karanth 2003). In India after commencement of Wildlife (Protection) Act, 1972 populations of large carnivores have increased and frequency and economic cost of conflict between humans and carnivores appears to be increased (Treves & Karanth 2003). Increasing human and livestock population put immense pressure on the natural habitats of wild animals and pose threat to wildlife conservation (Mishra 1997). Intensive grazing by domestic cattle and other activities of local people have been degrading tiger habitats in terms of retarded growth of vegetation, increase in abundance of weeds and ultimately depletion of natural prey base (Madhusudan 2000). As a consequence of increase in livestock and depletion of prey base, carnivores are compelled to prey on the domestic livestock.

Persecution by human beings in response to tiger-human conflict, along with decline of prey base, degradation of habitat and poaching, is the major cause of decline of tiger in recent past (Nyhus & Tilson 2004). Intentional killing of carnivores by humans is a major and rising threat to carnivore population viability (Rabinowitz 1986, Jhala & Giles 1991, Bangs et al. 1998, Woodroffe & Ginsburg 1998, Landa et al. 1999, Treves & Karanth 2003). For successful large carnivore conservation, it is essential to maintain a low level of conflict with humans (Decker & Chase 1997, Loe & Roskaft 2004). Most of tiger habitats have human settlements and tiger shares its range with humans. So in this human dominated landscape, tiger conservation is a very complex practice and we cannot succeed until and unless we have the support of the people living in and around the tiger habitats. Presently conflict with the local people is the biggest challenge for the managers of PAs and the conservationists all over the world. Prevention and mitigation of human-carnivore conflict must be based on an improved understanding of carnivore ecology and public acceptance of wildlife management and it must be drawn upon accumulated empirical knowledge and local experience (Treves & Karanth 2003). A management strategy to resolve or reduce tiger-human conflict requires sound understanding of ecology and behaviour of tigers, nature and extents of the problem, land use pattern and circumstances under which tiger-human conflicts take place in and around the protected areas (Chauhan 2005). Therefore, to find out solution for such a complex problem, first it is crucial to have the thorough understanding of the problem. But very little scientific information is available on the genesis of tiger-human conflict and mitigation strategies from different tiger areas in India (Chauhan 2005).

In Corbett Tiger Reserve (CTR) with highest density of tiger all over the world (Contractor 2007), large carnivores (tiger and leopard) attack significant number of cattle and create apathy among the local people toward conservation of large carnivores. One of the objective of the study was to study extent and characteristics of loss caused to local people by tiger in and around the buffer zone of the CTR. Such information is a prerequisite to develop effective management strategies to mitigate conflict that ultimately threaten the survival of tigers in human dominated landscapes.

4.2 Methodology

4.2.1 Data collection

To get a preliminary understanding of problem of tiger-human conflict, information on livestock attacks by tigers during 2001 and 2002, was collected from the forest administration of the CTR. Analysis of the forest department data showed that, problem was more severe on south-eastern limit of the study area. On the basis of this, whole of the buffer zone (BZ) of the CTR was divided into two zones *viz.* intensive (south-eastern portion) and extensive (northern portion) study area (Map 19).

Due to the logistic constraints, it was not possible to reach every reported-site of carnivore attack on time. So, I gathered secondary information of attacks on monthly basis from uncovered areas of the northern zone (extensive area) for which I could not collect GPS locations.

To study carnivore human conflict in detail, carnivores attacks on livestock and human beings, reported by the villagers and forest personnel, were inspected physically to establish the identity of the predator involved and to understand the factors responsible for cattle attack. The predator was identified on the basis of pattern of feeding, pugmarks, hairs and other indirect evidences. Mostly, tigers would start feeding from the rump portion. The size of the prey also indicates the predator, since leopards mostly prey upon medium sized animals. Data on location, predator species, and species killed, health, weight, age and sex of species was recorded. The exact location of cattle kill was recorded using a Global Positioning System (GPS, Magellan 310) receiver to identify areas with severe tiger-human conflict and to determine the spatio-temporal pattern of cattle attacks within study area.

4.2.2 Analysis

To determine the pattern and spatio-temporal nature of problem, locations of cattle killed and injured by tigers during the current investigation were plotted on the digitized map of the buffer zone of the CTR. Forest blocks were delineated into low, medium and high conflicting areas, based on number of attacks in each forest block. Similarly villages were categorized on the basis of number of attacks in three categories such as low, medium and high. Data was pooled on monthly and seasonal basis to see variation of attacks among months and seasons.

Economic loss incurred to locals due to livestock killed by tigers, was estimated based on the current market price of the species killed. Livestock species were categorised in different age classes as Adult (>5 year), Sub-adult (3 to 5 year), calf (1.5 to 3 year) and weaner (<1.5 year). Chi square goodness of fit test was used to test significance difference in livestock attacked by tiger among various seasons and livestock categories.

4.3 Results

4.3.1 Human attacks

Over the period of 5 years, from 2002 to 2006, 47 humans were attacked by the wild animals in and around buffer zone of the CTR. Out of which only 4 were killed and rest were injured by wild animals. Table 4.1 provides the details of humans attacked by different wild animals in and around the buffer zone of the CTR. Tiger contributed 40.2% (n=19) to attacks on humans and emerged as the most conflicting species while bear, wild pig and leopard contributed 21.3% (n=10), 21.3% (n=10) and 10.6% (n=5) of the total number of attacks on humans, respectively.

Tigers killed 3 humans while injured 16 humans during the 5-year period. Figure 4.1 shows the distribution of tiger attacks in different years. Out of 19 cases of tiger attacks, 14 victims were males and rest were females. All the tiger attacks were reported from the south-eastern boundary of the CTR.

Table 4.1: Number of humans killed/injured by wild animals (2002-06) in and around the buffer zone of the CTR

S. No.	Animal Involved	Injury	Death	Total
1	Tiger	16	3	19
2	Bear	10	0	10
3	Wild Pig	10	0	10
4	Leopard	4	1	5
5	Elephant	2	0	2
6	Blue bull	1	0	1
Total		**43**	**4**	**47**

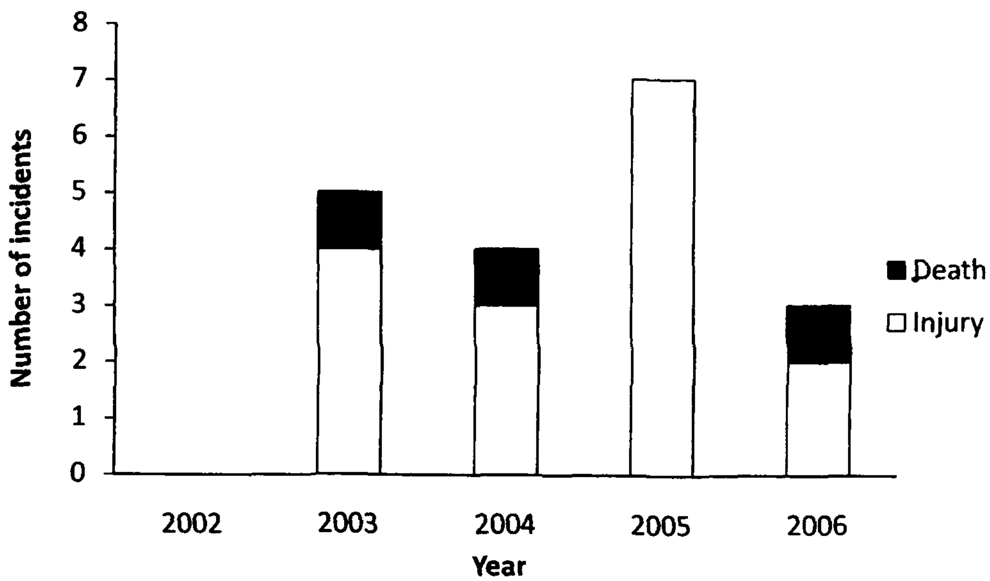


Figure 4.1: Number of humans killed or injured by tigers in and around the buffer zone of the CTR from 2002 to 2006.

During 2002, no attacks on humans by tiger was reported, whereas maximum number of attacks (n= 7) were reported during 2005 and minimum number of attacks (n=3) were reported during 2006. Tiger injured 4, 3, 7 and 2 humans during 2003, 2004, 2005, and 2006 respectively, whereas one human death was reported in each year during 2003, 2004 and 2006.

Repercussions of tiger attack

Local people react very aggressively after attack of tiger on humans and managers of the PAs face most challenging jobs in such a situation. They have very pathetic situation and face tremendous pressure from the local people to eliminate or capture the tiger. Situations became more strenuous when attacks on human leads to death and people assume that tiger has become a man-eater.

In response to a lady killed in 2003 from Tera village, local people agitated and put pressure on the forest department to eliminate or capture the tiger that killed the lady. Under the pressure of local people and local politicians, forest department started a capture operation, for the responsible tiger. After rigorous effort, forest department successfully captured the tiger and sent it to the Nanital Zoo. Due to the stress, the tiger died in the Zoo, and same fate was of the tiger that killed one person in 2004.

In response to fear created by tiger in Mohan village, under the pressure of local people and media, forest department started a capture operation. During this operation, the tiger jumped on the vehicle and elephant of capture team. The tiger was found dead on October 13th, 2005 just outside the Mohan village. Cause of death could not be ascertained with certainty, most probably succumbed to injuries incurred.

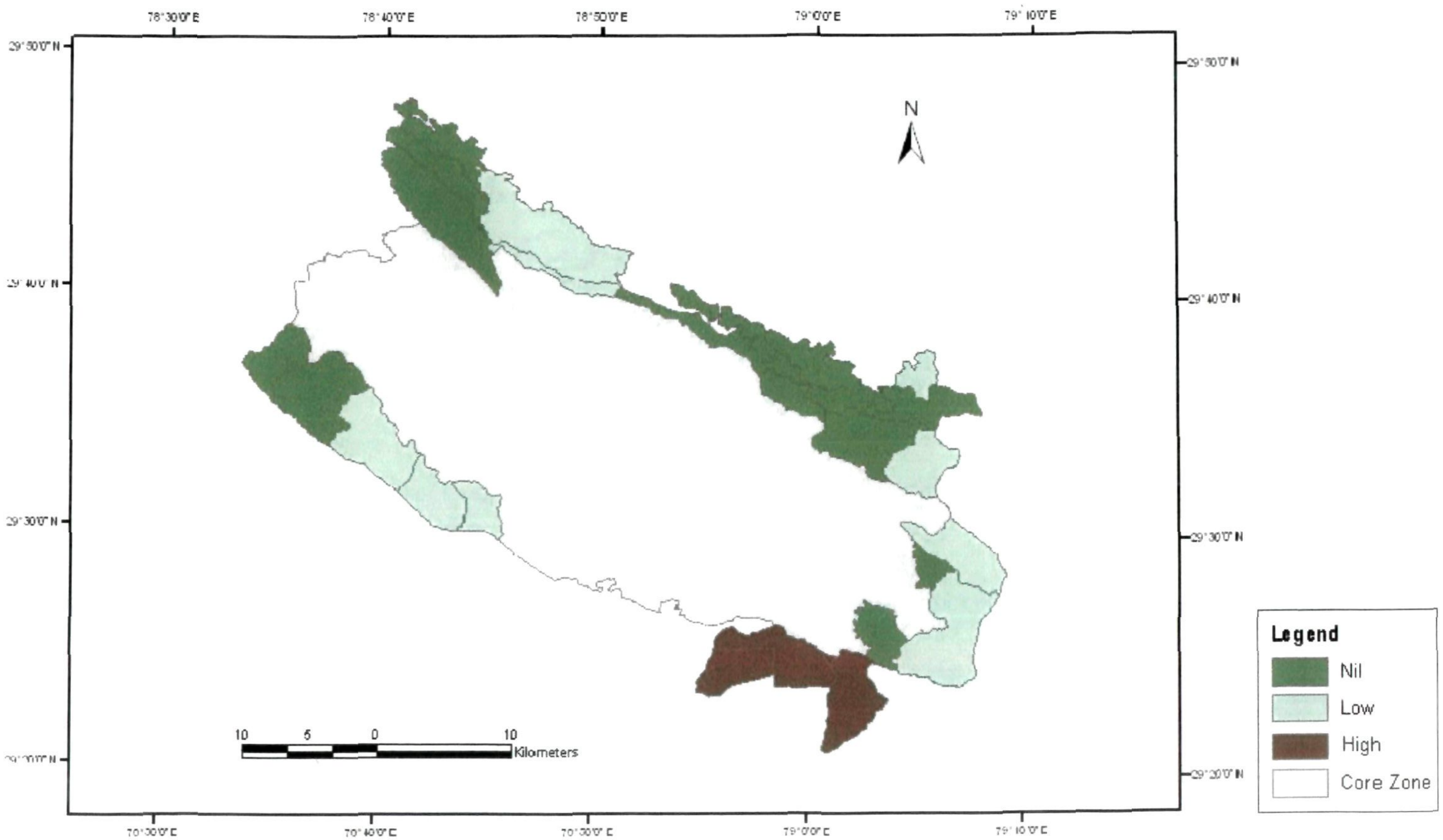
The exception was the year 2006, in response to woman killed by a tiger; behaviour of local people of Dhela village was highly commendable. They fully cooperated with the managers of the CTR and did not take any negative action towards the tiger responsible for the killing of the woman.

In most of the cases of tiger's attack on humans, forest department and The Corbett Foundation provided monetary support to the affected people, which helped to reduce the negative perception of local people towards tigers. During the study period, 3 tigers were eliminated from in and around the buffer zone of the CTR in response of tiger-human conflict and it is a threat to the long-term conservation of tigers.

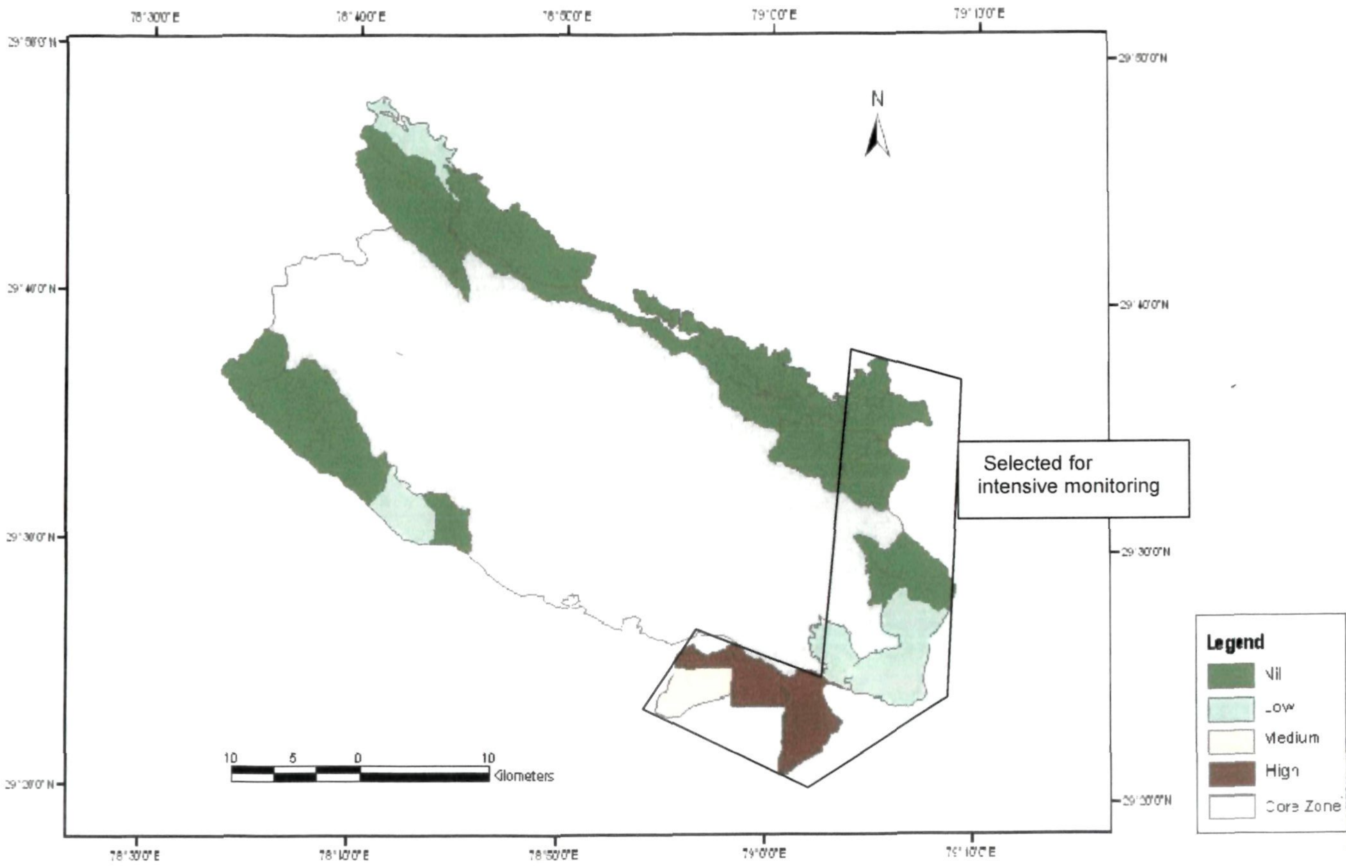
4.2.2 Livestock depredation

(A). Spatial Pattern of Problem

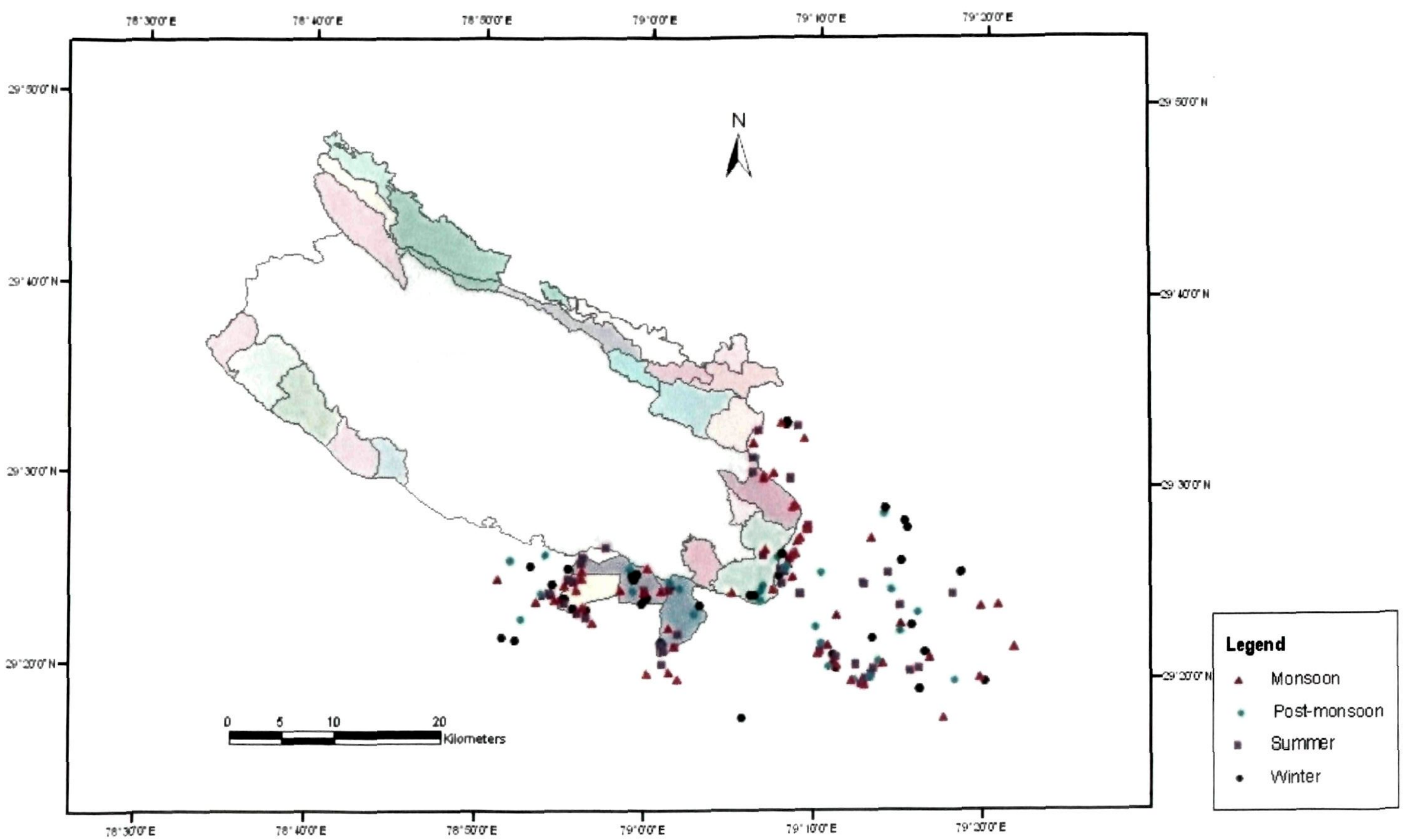
Intensity of livestock depredation, based on the forest department data for the years 2001 and 2002, is provided in Table 4.2. Three blocks have high incidences of livestock attack by tigers, 9 blocks with low number of attacks while the remaining 14 blocks have no records of livestock kill during 2001. During 2002 the number of block without livestock kills increased substantially from 14 to 19 whereas the number of blocks with low number of livestock decreased from 9 to 4. There were only 2 blocks with high levels of livestock depredation in 2002. Maps 10 and 11 provide block wise pattern of livestock depredation in buffer zone of the CTR. Most of the affected forest blocks were in the southeast of the buffer zone. All the blocks in the north, east and the west of the buffer zone either had no cattle depredation or low-level of cattle depredation. Number of blocks, free of livestock depredation in the north of the buffer zone, increased from 2001 to 2002. Similar trends were observed in the blocks of both east and west of the buffer zone, between these years (Appendix III).



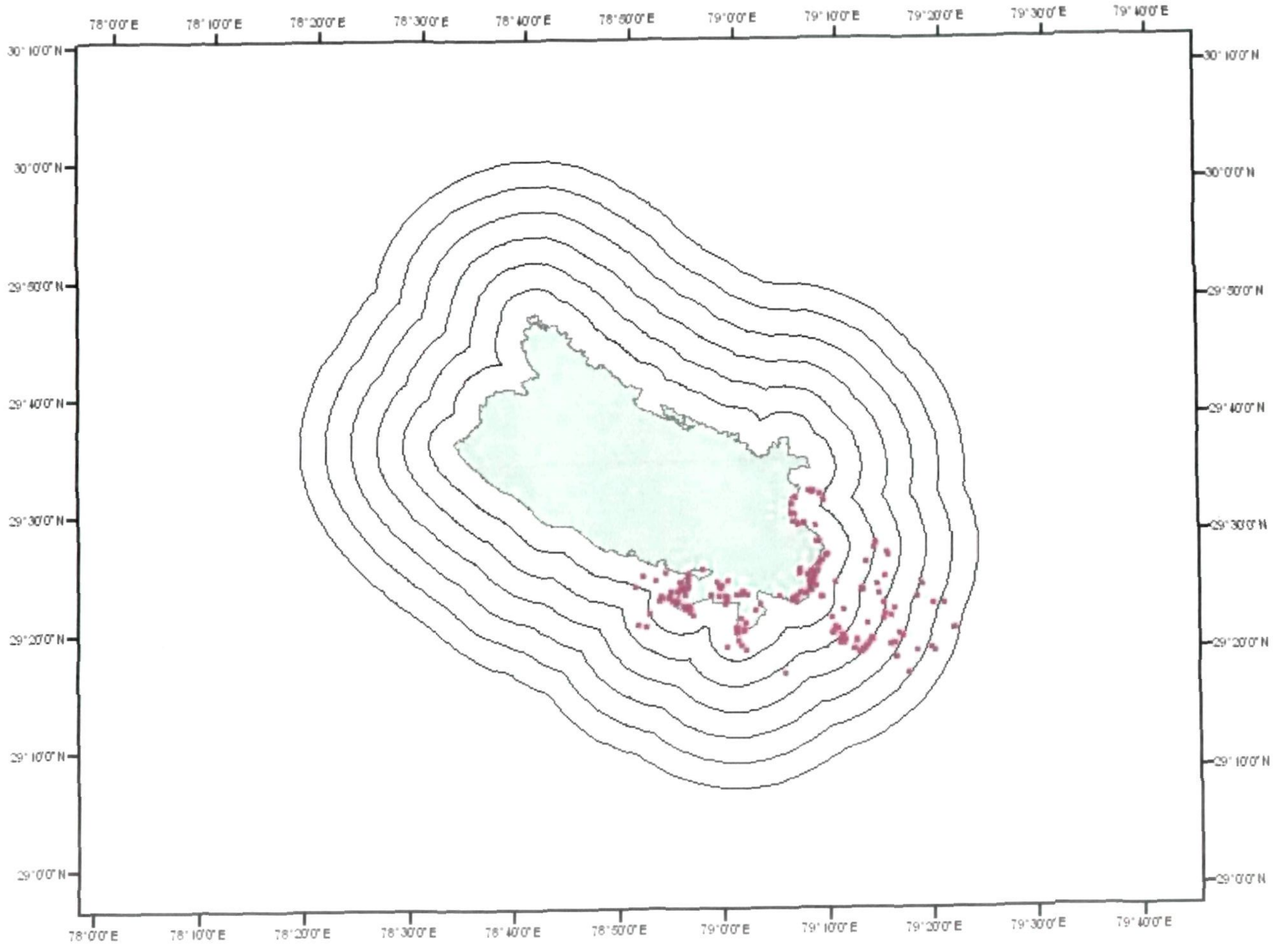
Map 10: Block wise pattern of livestock depredation in buffer zone of the CTR (2001)



Map 11: Block wise pattern of livestock depredation in buffer zone of the CTR (2002)



Map 12: Spatial representation of livestock depredation by tiger in and around buffer of CTR



Map 13: Distribution of livestock killed by tiger in around buffer zone of the CTR with 5 km buffer

Table 4.2: Block-wise intensity of livestock depredation by tigers in the buffer zone of the CTR

Year	Nil (%)	Low (%)	Medium (%)	High (%)
2001	14 (53.9)	9 (34.6)	0 (0)	3 (11.5)
2002	19 (73.1)	4 (15.4)	1 (3.9)	2 (7.7)

Source: Forest Department data

These results, presented in maps 10 and 11, are based on the data collected by the forest department and include only those cases which occurred inside the boundary of the CTR, therefore, do not provide a clear picture of livestock depredation by tigers in and around the buffer zone of the CTR. However, it was clear that there was severe tiger-human conflict in and around the south-eastern peripheral settlements of the CTR. Maps 12 and 13 provide the spatial representation of intensity of livestock depredation in and around southern periphery of the buffer zone of the CTR.

(B). Economic assessment of loss (Overall)

Number of attacks and livestock killed

During 5 years period (2002-06), 3027 incidents of carnivore (tiger and leopard) attacks on livestock, were recorded in and around the periphery of the CTR. Tigers killed 1418 cattle with an average rate of 284 livestock per year and injured 506 cattle with an average rate of 101 livestock per year. Tigers killed 241, 245, 306, 293, and 333 cattle while injured 80, 55, 109, 136, and 126 cattle in 2002, 2003, 2004, 2005, and 2006 respectively. The livestock attacked by tigers during 5 years period (2002-06) were from 166 villages. Tigers attacked 1924 animals with an average rate of 12 animals/ village.

Leopards killed 977 cattle with an average 195 livestock/year and injured 126 with 25 cattle/year. Leopard killed 163, 179, 161, 236, and 238 while injured 13, 23, 38, 30, and 22 cattle in 2002, 2003, 2004, 2005, and 2006 respectively. The livestock killed by leopard were from 160 villages.

Composition of age and sex of the species

Table 4.3 provides the characteristics of livestock attacked by tigers in and around the buffer zone of the CTR. Distribution of livestock attacked by tigers differed significantly among the different livestock classes (χ^2 = 2484.79, d.f. = 7, P<0.001). Tigers attacked more cows (37.7%), followed by buffaloes (35%), whereas attacked less bullocks (11.4%), buffalo calves (6.7%), cow calves (5%), horse (0.2%) and mule (0.1%). On comparison of livestock killed and injured separately, it was to found that tiger killed more cows in comparison to buffaloes but injured more buffaloes in comparison to cows.

Table 4.3: Numbers and characteristics of livestock attacked by tiger in and the around the Corbett Tiger Reserve (Overall, 2002-2006)

S.NO.	Livestock class	Killed	Injured	Total
1	Cow	555	171	726
2	Bullock	174	46	220
3	Cow calves	78	27	105
4	Buffalo	469	204	673
5	He-Buffalo	51	14	65
6	Buffalo calves	85	44	129
7	Horse	4	0	4
8	Mule	2	0	2
	Total	**1418**	**506**	**1924**

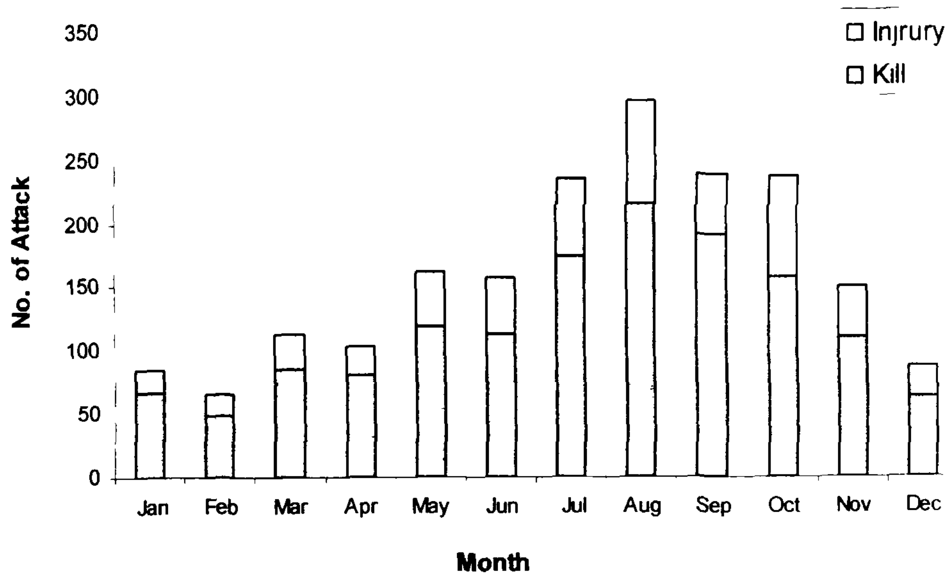


Figure 4.2: Month-wise distribution of livestock attacked by tiger in and around the Corbett Tiger Reserve (2002-06)

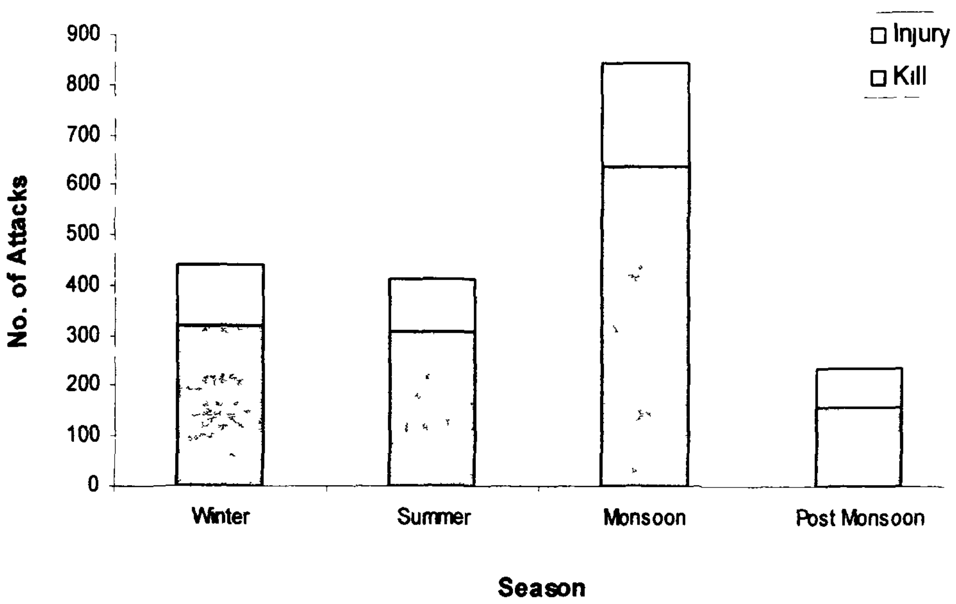


Figure 4.3: Season-wise distribution of livestock attacked by tiger in and around the Corbett Tiger Reserve (2002-06)

Figure 4.2 provides the distribution of livestock killed and injured in different months over five year period (2002-06). The distribution of tiger attacks on livestock differed significantly in different months (χ^2 = 153.73, d.f. = 11, P<0.001). Majority (57%) of cattle attacks were recorded during the months of August (n= 335), September (n= 237), October (n= 236) and July (n= 234).

The distribution of tiger attack on cattle differed significantly between seasons (χ^2 = 104.51, 'd.f. = 3, P<0.001). Frequency of tiger's attack on livestock was highest (n=209) in monsoon. There were 85 and 91 incidents of tiger attacks during winter and summer respectively while only 74 incidents of tiger attack on cattle were recorded during post monsoon (Figure 4.3).

Economic loss

From 2002-2006, 3027 attacks of large carnivores on cattle were recorded with an average of 12 livestock/ week. Tigers attacked 7 cattle/ week. Out of 506 livestock injured by tigers, 137 died afterwards. To determine the impact of depredation in terms of economic loss, incidents of livestock died due to injury caused by tiger was also included. Table 4.4 provides the presentation of various age and sex classes of livestock species and their associated economic cost. Cows, buffaloes and bullocks were most frequently depredated by tigers and form largest component of economic loss. From 2002 to 2006, tigers were responsible for estimated economic loss of Rs. 11,666,750 to people sharing range with tiger in and around the buffer zone of the CTR. Over period of 5 year, maximum loss was recorded in 2006 (Rs. 27, 39,500) while minimun in 2002 (Rs. 19, 47,750).

Table 4.4: Economic loss incurred to livestock owners over a period of 2002-06

Livestock Class	Estimated Cost	Individuals Killed					
		2002	2003	2004	2005	2006	Overall
Buffalo	12,000	69	70	85	66	81	371
Buffalo (SA)	8,000	3	11	11	21	18	64
He-Bufffalo	12,000	1	0	3	5	3	12
He-Buffalo	8,000	1	0	0	2	3	6
Buffalo calf	2,000	23	19	22	32	15	111
Buffalo	1,000	0	1	4	0	4	9
Cow	7,000	95	93	138	133	169	628
Cow (SA)	5,000	0	5	12	14	2	33
Bullock	7,000	40	44	38	38	42	202
Bullock (SA)	5,000	3	1	5	8	4	21
Cow calf	1,500	25	11	17	13	15	81
Cow weaner	750	3	2	5	1	0	11
Horse	15,000	2	0	0	0	0	2
Mule	10,000	0	1	1	2	0	4
Total Livestock Killed		**265**	**258**	**341**	**335**	**356**	**1555**
Total Loss		**19,47,750**	**19,84,000**	**25,48,250**	**24,47,250**	**27,39,500**	**1,16,66,750**

(a). 2002

Number of attacks and livestock killed

During 2002, 497 attacks on livestock by big cats (tigers and leopards) were recorded in and around the buffer zone of the CTR to determine the pattern and nature of carnivore predation on livestock. Tigers killed 241 and injured 80 animals while leopard killed 163 and injured 13 animals. Out of 80 cattle injured by tigers, 24 died afterwards. Although leopard killed smaller livestock species like goat and sheep but since no prey remains were left so they could not be quantified.

Dhela (n=28), Phanto (n=24), Kyari (n=14) and Sunderkhal (n=12) were the villages affected most severely due to tiger-human conflict and have the maximum number of livestock killed and injured by tigers. Out of these 4 human settlements, Dhela village is inside the buffer zone of the CTR whereas two, Phanto and Sunderkhal, were located adjoining to the buffer zone of the CTR and fourth, Kyari, was in Ramnagar Forest division.

Composition of age and sex of the species

Distribution of livestock attacks by tigers significantly differed among the different livestock classes (χ^2 = 179.05, d.f. = 6, $P<0.001$). Tigers depredated more buffaloes (39.6%), followed by cows (35.8%) while attacked less on bullocks (15.3%), buffalo calves (3.4%), cow calves (4.7%) and 0.6% he-buffalo and horse each. On consideration of incidents of cattle killed and injured by tigers separately, it was found that tigers killed more cows in comparison to buffaloes but injured more buffaloes than cows. (Table 4.5)

Figure 4.4 provides the distribution of livestock killed and injured in different months during 2002. The distribution of tigers attack on livestock differed significantly in months (χ^2 = 67.44, d.f. = 11, $P<0.001$) and majority (58.67%) of cattle attacks were recorded during the month of July (n= 45), August (n= 45), October (n=39) and September (n= 37).

Table 4.5: Number and characteristics of livestock attacked by tiger (2002) in and around the Corbett tiger Reserve

S.NO.	Livestock class	Killed	Injured	Total
1	Cow	100	15	115
2	Bullock	42	7	49
3	Cow calves	15	0	15
4	Buffalo	72	55	127
5	He-Buffalo	2	0	2
6	Buffalo calves	8	3	11
7	Horse	2	0	2
	Total	**241**	**80**	**321**

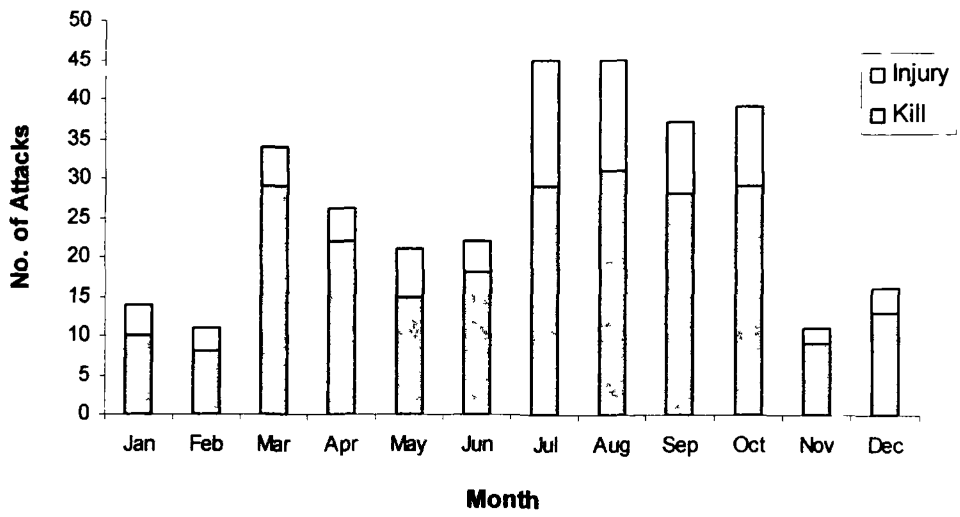


Figure 4.4: Month wise distribution of livestock killed and injured by tiger in and around the Corbett Tiger Reserve (2002)

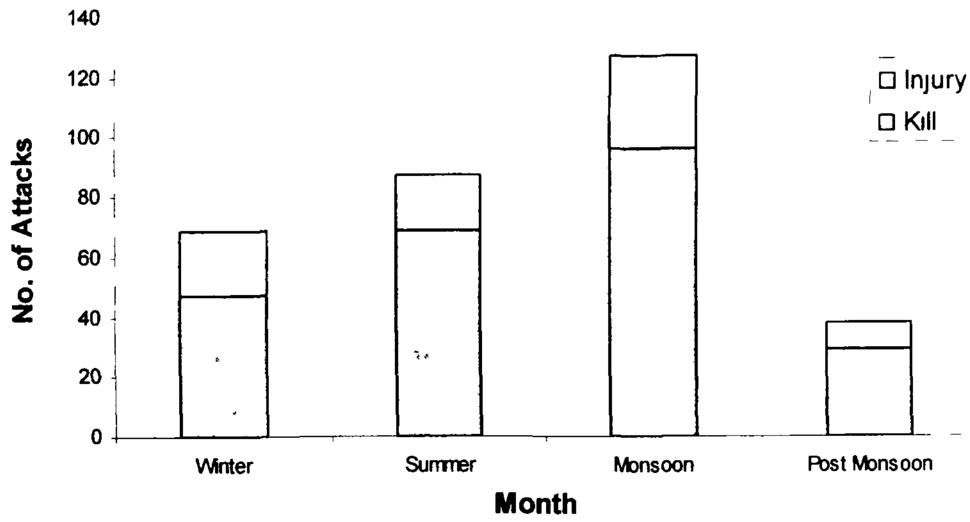


Figure 4.5: Season wise distribution of livestock killed by tiger in and around the Corbett Tiger Reserve (2002)

The distribution of tiger attacks on cattle differed significantly between seasons (χ^2 = 51.62, d.f. = 3, P<0.001). Frequency of tiger's attack was maximum during monsoon (n=96). There were 87 and 69 incidents of tiger attacks during summer and winter respectively while, only 38 incidents of tiger attacks on cattle were recorded during post monsoon (Fig 4.5).

Economic loss

In 2002, 497 attacks of large carnivores (leopards and tigers) on cattle were recorded with an averaged 10 livestock/ week. Tigers attacked 6 cattle/ week. Out of 80 livestock injured by tigers, 22 died afterwards. Tigers were responsible for an estimated loss of about Rs. 1,947,750 in 2002 (Table 4.4).

(b). 2003

Number of attacks and livestock killed

During 2003, 502 attacks on livestock by big carnivores (tigers and leopards) were recorded in and around the buffer zone of the CTR. Tigers killed 245 and injured 55 animals while leopards killed 179 and injured 23 animals. Out of 55 cattle injured by tigers, 13 died afterwards. Tera (n= 24), Dhela (n=22), Phanto (n=15) and Mohan (n=11) are villages that were affected severely during the year 2003.

Composition of age and sex of the species

Table 4.6 provides the characteristics of livestock attacks by tigers in and around the CTR. Distribution of livestock attacked by tigers differed significantly among the different livestock classes (χ^2 = 272.19, d.f. = 6 P<0.001). Tigers attacked more cows (34.7%) followed by buffaloes (33%), whereas attacked less bullocks (20%), buffalo calves (7.3%), cow calves (4.7%) and mule (0.3%).

Figure 4.6 provides the distribution of livestock killed and injured in different months during 2003. The distribution of tiger attacks on livestock differed significantly among different months (χ^2 = 54.64, d.f. = 11, P<0.001). Majority (59%) of cattle attacks were recorded during September (n= 44), November (n= 36), October (n= 33), July (n= 32) and August (n= 32).

The distribution of tiger attacks on cattle differed significantly between seasons (χ^2 = 52.8, d.f. = 3, P<0.001). The frequency of tiger's attack was maximum (n=121) during monsoon. There were 79 and 67 incidents of tiger attacks during winter and summer respectively while only 33 incidents of tiger attacks on cattle were recorded during post monsoon (Fig 4.7).

Table 4.6: Numbers and characteristics of livestock attacked by tiger (2003) in and around the BZ of the CTR

S.NO.	Livestock class	Killed	Injured	Total
1	Cow	93	11	104
2	Bullock	45	15	60
3	Cow calves	13	1	14
4	Buffalo	77	22	99
5	He-Buffalo	0	0	0
6	Buffalo calves	16	6	22
7	Mule	1	0	1
	Total	**245**	**55**	**300**

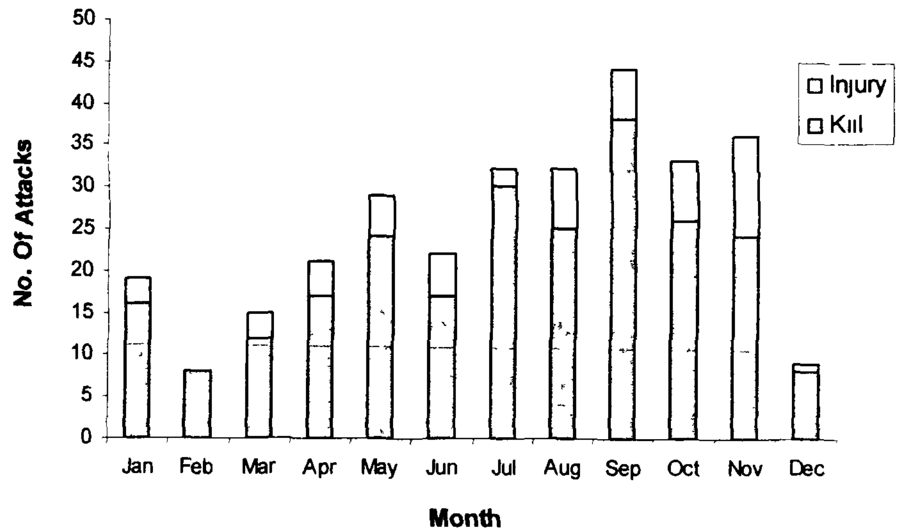


Figure 4.6: Month wise distribution of livestock killed by tiger in and around BZ of the CTR (2003)

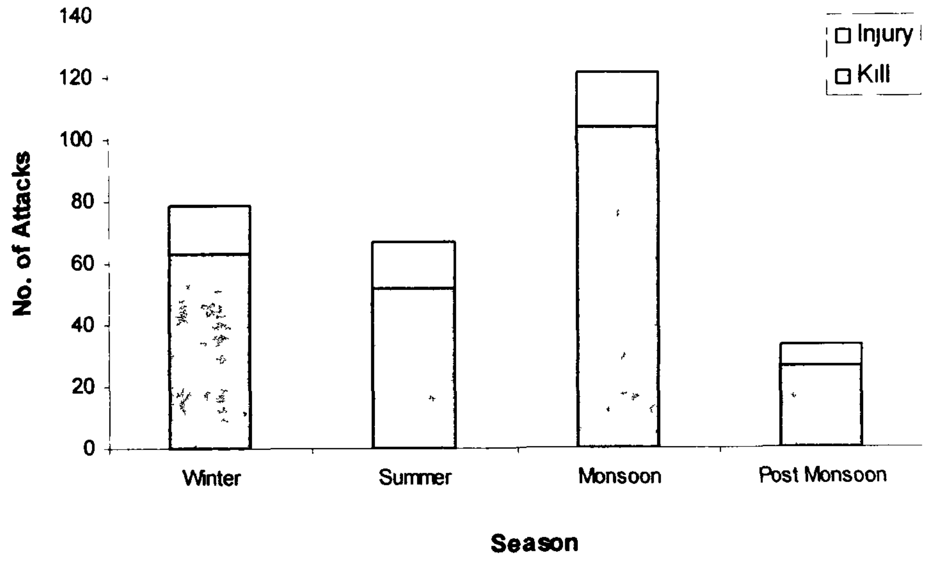


Figure 4.7: Season wise distribution of livestock killed by tiger in and around the BZ of the CTR (2003)

Economic loss

In 2003, 502 attacks of large carnivores on cattle were recorded at an average of 10 livestock attacks/ week. Tigers depredated 6 cattle/ week. Out of 55 livestock injured by tigers 13 died later. Cows, buffaloes and bullocks were most frequently depredated by tigers and represent largest component of economic loss. Tigers were responsible for estimated economic loss of Rs. 19,84,000 in 2003 (Table 4.4).

(c). 2004

Number of attacks and livestock killed

During 2004, 612 attacks on livestock by big carnivores (tigers and leopards) were recorded in and around the BZ of the CTR. Tigers killed 306 and injured 109 animals while leopards killed 161 and injured 36 animals. Out of 109 cattle injured by tigers, 35 died afterwards. Dhela (n=27), Tera (n=23), Mankandhpur (n=19) and Phanto (n=17) were the villages affected severely during 2004.

Composition of age and sex of the species

Table 4.7 provides the characteristics of livestock attacked by tigers in and around the CTR. Distribution of livestock attacked by tiger differed significantly among the different livestock classes (χ^2 = 444.11, d.f. = 6 P<0.001). Tigers attacked more cows (42.89%) followed by buffaloes (29.4%), whereas attacked less bullocks (12.1%), buffalo calves (8.4%), cow calves (6%) and mule (0.2%).

Table 4.7: Numbers and characteristics of livestock attacked by tiger in and around buffer zone of the CTR in 2004

S.NO.	Species	Killed	Injured	Total
1	Cow	139	39	178
2	Bullock	40	10	50
3	Cow calves	18	7	25
4	Buffalo	86	36	122
5	He-Buffalo	3	1	4
6	Buffalo calves	19	16	35
7	Mule	1	0	1
	Total	**306**	**109**	**415**

Figure 4.8 provides the distribution of livestock killed and injured in different months in 2004. The distribution of tiger attacks on livestock differed significantly in different month (χ^2 = 123.1, d.f. = 11, P<0.001) and majority (62.9%) of cattle attacks were recorded during the month of August (n=76), July (n=57), September (n= 50) and October (n= 39) June (n= 39).

The distribution of tigers attacks on cattle differed significantly between different seasons (χ^2 = 128.7, d.f. = 3, P<0.001). Frequency of attacks was maximum (n=197) during monsoon. There were 84 and 95 incidents of tiger attacks during winter and summer respectively while only 39 incidents of tiger attacks on cattle were recorded during post monsoon (Figure 4.9).

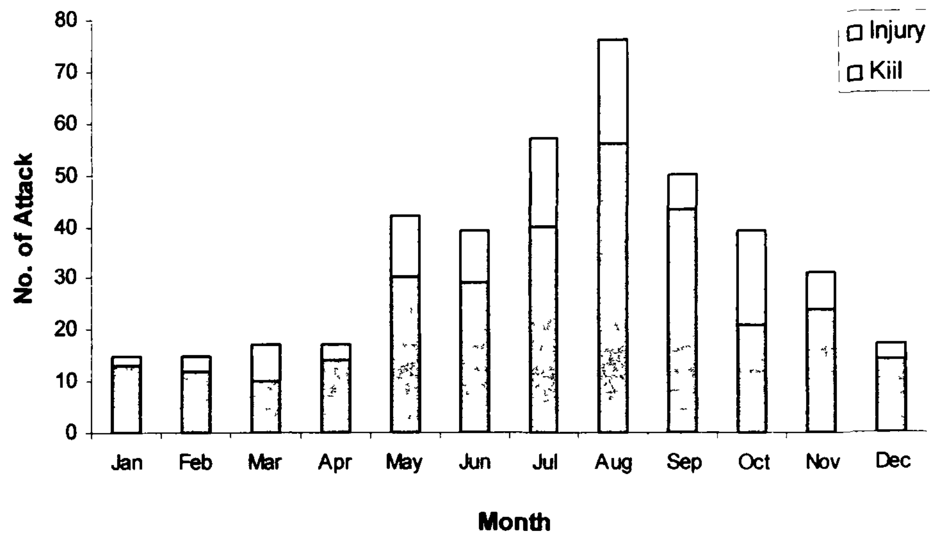


Figure 4.8: Month wise distribution of livestock attacked by tiger in and around the buffer zone of the CTR (2004)

Economic loss

In 2004, 612 attacks of large carnivores (tigers and leopards) on cattle were recorded with an average 12 livestock/ week. Tigers attacked 8 cattle every week. Out of 109 livestock injured by tigers, 35 died later. Cows, buffalos and bullocks were most frequently depredated by tigers and represent largest component of economic loss. Tigers were responsible for estimated economic loss of Rs. 2,548,250 in 2004 (Table 4.4).

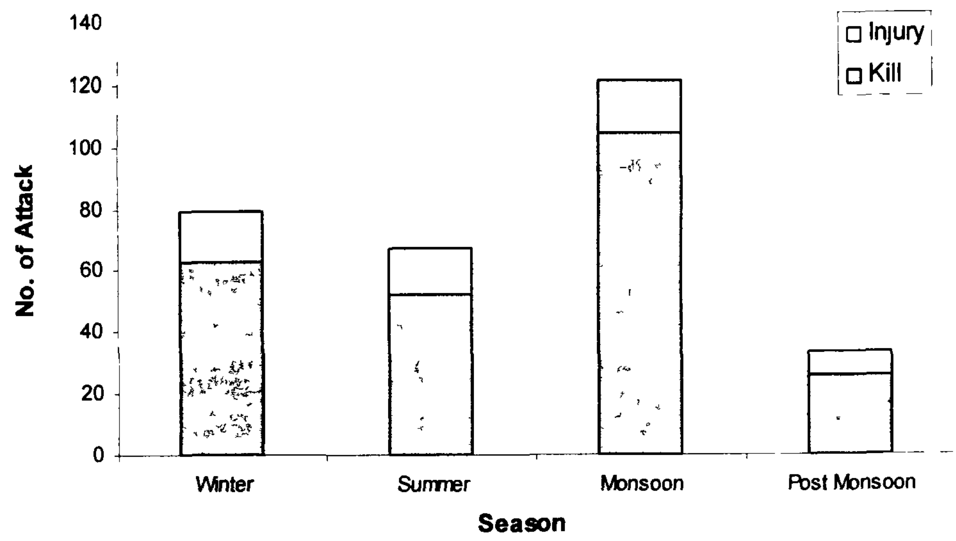


Figure 4.9: Season wise distribution of livestock attacked by tiger in and around the BZ of the CTR (2004)

(d). 2005

Number of attacks and livestock killed

During 2005, 695 attacks on livestock by big carnivores (tigers and leopards) were recorded in and around the BZ of the CTR. Tigers killed 293 and injured 136 animals whereas leopards killed 236 and injured 30 animals. Out of 136 cattle injured by tigers, 42 died later. Tera (n= 34), Dhela (n=33), Belghatti (n=21) and Patrani (n=17) are the villages that were affected severely during 2005.

Composition of age and sex of the species

Table 4.8 provides the characteristics of livestock attacked by tigers in and around the CTR. Distribution of livestock attacked by tiger significantly differed among the different categories of livestock (χ^2 = 420.82, d.f. = 6 P<0.001). Tigers attacked more cows (39.6%) followed by buffaloes (31.2%), whereas attacked less bullocks (12.8%), buffalo calves (9.8%), cow calves (4.4%) and horse (0.4%).

Figure 4.10 provides the distribution of livestock killed and injured in different months during 2005. The distribution of tiger's attack on livestock differed significantly in different months (χ^2 = 65.07, d.f. = 11, P<0.001). Majority (48.7%) of cattle attacks were recorded during the month of August (n= 67), October (n= 51), July (n= 50) and September (n= 41).

Table 4.8: Numbers and characteristics of livestock attacked by tiger in and around the BZ of the CTR (2005)

S.NO.	Species	Killed	Injured	Total
1	Cow	134	36	170
2	Bullock	41	14	55
3	Cow calves	14	5	19
4	Buffalo	70	64	134
5	He-Buffalo	6	1	7
6	Buffalo calves	26	16	42
7	Horse	2	0	2
	Total	**293**	**136**	**429**

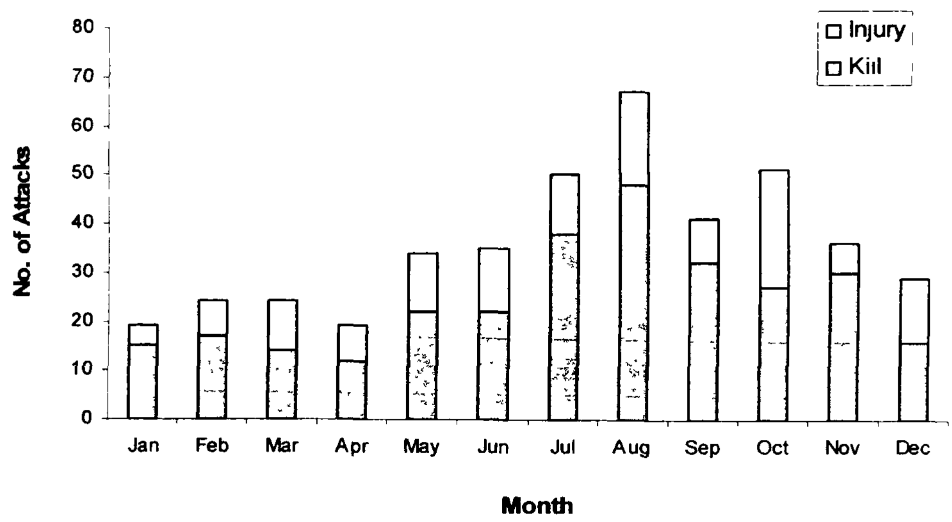


Figure 4.10: Month wise distribution of livestock attacked by tiger in and around the BZ of the CTR (2005)

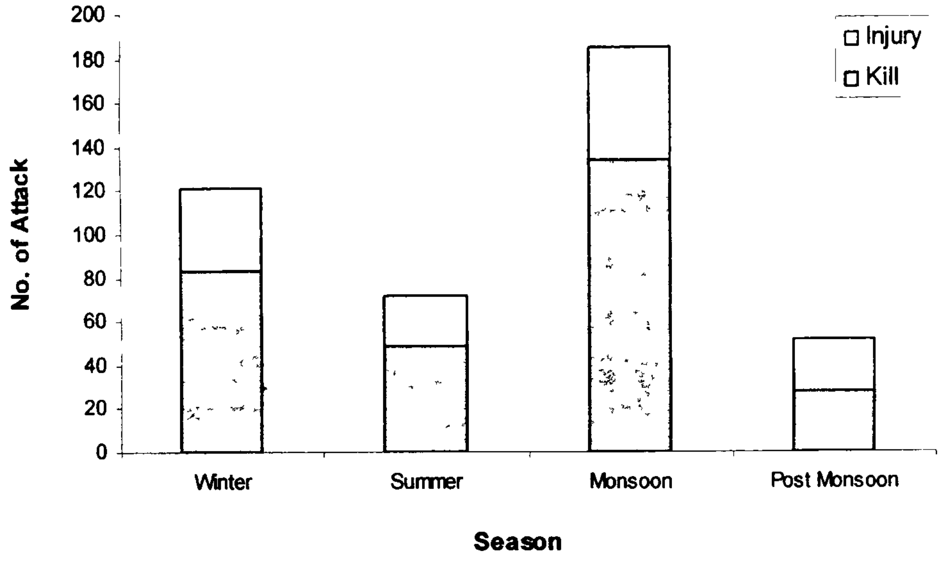


Figure 4.11: Season wise distribution of livestock attacked by tiger in and around BZ of the CTR (2005)

The distribution of tiger attacks on cattle differed significantly between seasons (χ^2 = 99.21, d.f. = 3, P<0.001). Frequency of tiger's attack was maximum (n=185) during monsoon. There were 121 and 72 incidents of tiger attacks during winter and summer respectively while only 51 incidents of tiger attack on cattle were recorded during monsoon (Figure 4.11).

Economic loss

In 2005, 695 attacks of large carnivores on cattle were recorded with an average of 13 livestock/ week. Tigers attacked 8 cattle/ week. Out of 136 livestock injured by tigers, 42 died later. Cows, buffalos and bullocks were most frequently depredated by tigers and represent largest component of economic loss. Tigers were responsible for estimated economic loss of Rs. 24, 47,250 during 2005 (Table 4.4).

(e). 2006

Number of attacks and livestock killed

During 2006, 719 attacks on livestock by big carnivores (tigers and leopards) were recorded in and around the BZ of the CTR. Tigers killed

333 and injured 126 animals while leopards killed 126 and injured 22 animals. Out of 126 cattle injured by tigers, 23 died later. Dhela (n=42), Tera (n= 29), Navigarh (n=25) and Belghatti (n=23) were the villages affected severely during 2006.

Composition of age and sex of the species

Table 4.9 provides the characteristics of livestock attacked by tigers in and around the BZ of the CTR. Distribution of livestock attacked by tigers differed significantly among the different livestock classes (χ^2 = 402.27, d.f. = 5, P<0.001). Tigers attacked more cows (41.6%) followed by buffaloes (34.6%), whereas attacked less bullocks (11.3%), buffalo calves (6.9%) and cow calves (4.1%).

Figure 4.12 provides the distribution of livestock killed and injured in different months during 2006. The distribution of tigers attacks on livestock differed significantly among different months (χ^2 = 153.73, d.f. = 11, P<0.001). Majority (57%) of cattle attacks were recorded during the month of August (n=75), October (n=74), September (n= 65) and July (n= 60).

The distribution of tiger attacks on cattle differed significantly between seasons (χ^2 = 104.51, d.f. = 3, P<0.001). Frequency of cattle attack was maximum (n=209) during monsoon. There were 85 and 91 incidents of tiger attacks during winter and summer respectively whereas only 74 incidents of tiger attacks on cattle were recorded during post monsoon (Fig 4.13).

Economic loss

In 2006, 719 attacks of large carnivores on cattle were recorded with an average of 14 livestock/ week. Tigers attacked 9 cattle/ week. Out of 126 livestock injured by tigers 24 died later. Table 4.12 represents various age and sex classes of livestock and their associated economic cost. Cows, buffaloes and bullocks were most frequently depredated by tigers and represent largest component of economic loss. Tigers were responsible for estimated economic loss of Rs. 27, 39,500 in 2006.

Table: 4.9: Numbers and characteristics of livestock attacked by tiger in and around the BZ of the CTR during 2006

S.NO.	Livestock class	Killed	Injured	Total
1	Cow	89	70	159
2	Bullock	6	0	6
3	Cow calves	18	14	32
4	Buffalo	164	27	191
5	He-Buffalo	40	12	52
6	Buffalo calves	16	3	19
	Total	**333**	**126**	**459**

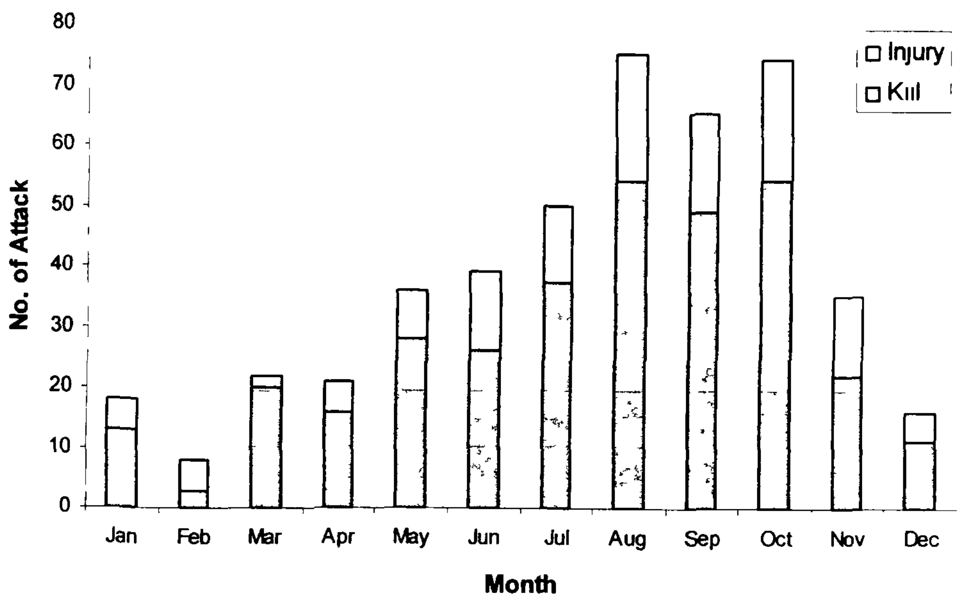


Figure 4.12: Month wise distribution of livestock attacked by tiger in and around the BZ of the CTR (2006)

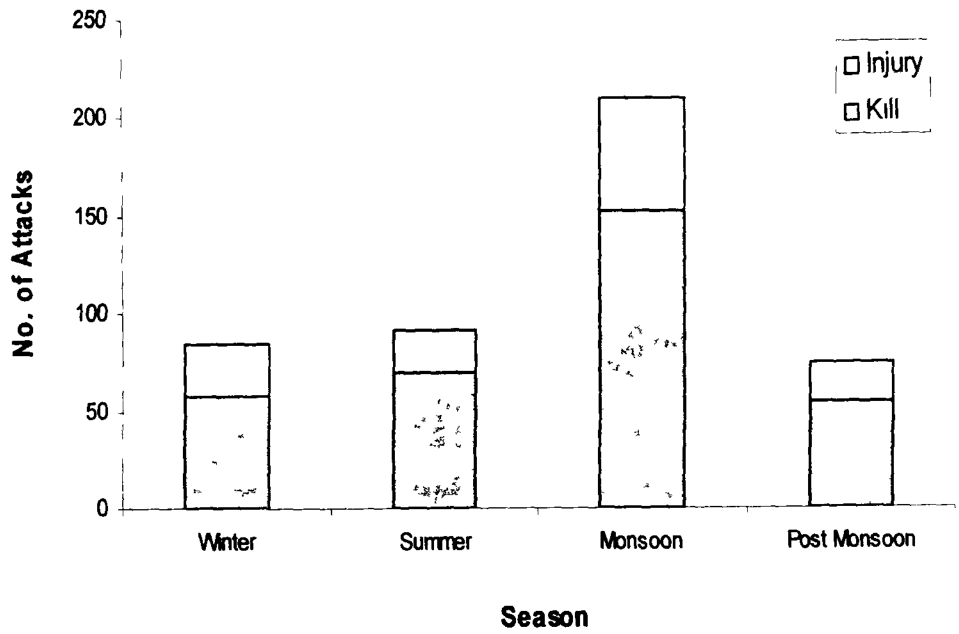


Figure 4.13: Season wise distribution of livestock attacked by tiger in and around the BZ of the CTR (2006)

4.4 Conclusion and discussion

Humans dominate the landscapes of most of the parts of the world, and human impact and movement go far beyond the edges of cities and into wild habitats. This incursion of humans into wild habitats, plus habituation of some wild species, has resulted in increased potential for human wildlife encounter, including wildlife attacks on humans (Quiley & Herrero 2005). Though there has been recent increase in our appreciation and understanding of importance of wildlife conservation, attacks on humans and their property tend to illicit strong negative response towards conservation of carnivores. Remaining tiger habitats in Indian sub-continent are like the islands surrounded by the land dominated by human populations and their future depend on the goodwill and support of people living around tiger habitats. Therefore, unless there are strong incentives to conserve tigers for the local people, it is impossible to ensure future survival of tiger. But, conflict between the local people and tiger create hindrance in the motivation of local people for the conservation of tiger. For the conservation measures to be successful, it is imperative that different forms of tiger-human conflicts should be managed. Effective conservation programme needs a constant process of mitigation of conflict and negotiation over the long term. For conservation to be effective we must constantly engage in multifaceted exploration of our relationship with natural environment and with each other.

Out of 19 incidents of tiger attacks on humans, tigers killed only three victims and this indicated that tigers are not attacking humans with the motive to consume. It is clear that tigers do not consider humans as prey and attacks on humans are purely accidental. Attacks on human beings have been considered an aberrant form of behaviour of tigers (Chauhan 2005). In CTR, large number of people enters daily into forests for collection of NTFPs (Non timber forest produces) and to graze livestock and presence of large number of humans in tiger range gives rise to high probability of encounters with tigers. Therefore, incidents of tiger attack on humans would consequently be more if tiger consider human as occasional prey. In the study period, only three cases of deaths were reported during five year time span. Three human deaths over a period of 5-year were quite low in comparison to Sundarbans where Hendrichs (1975) reported 24.3 deaths per year over a period of 15-years of study. Therefore, these insignificant incidences of human attacks clearly indicated that tigers responsible for attacks were not man eaters and occasional attack on humans was the result of sudden close encounter of humans with tiger and in response to self security or protecting their cubs. But, in spite of low number of incidents, this is the most intolerable form of conflict and needs some strategies to reduce tiger attacks on humans. Though, local people cannot be legally denied entry into the buffer areas but they can be given practical skills and trained to defend themselves, to avoid any potential attack by tigers. Reducing attacks not only reduces injury and loss of life of human population but can help into conserving wildlife populations, promote good will towards wildlife, minimise economic loss and improve quality of life for humans (Quiley & Herrero 2005).

Tigers attacked more males (n= 14) in comparison to females (n= 5) and similar trend was also reported from Katerniaghat Wildlife Sanctuary (Chauhan 2005), where he discussed that males go to forests more in comparison to females and are more vulnerable to tiger attacks. But, the situation in the CTR is different; mostly women in groups go inside the forests to collect fodder and fuel wood. Human settlements are scattered in and around forests and local people (generally men) have to commute through tiger habitats when they move outside for work. Mostly, they go early in the morning for work and come late in the evening and these timings coincide with the crepuscularity of tiger thus, becoming more vulnerable to attacks. Secondly, women always move in groups while, men mostly move solitary or less in number and this makes men more vulnerable to tiger attack in comparison to women. But, tiger killed more females in comparison to males. That is because males are generally stronger in comparison to females and has high chance of surviving as compared to females. Females got frightened easily and ran away when tiger attacked its fellow member while male develop courage to save his fellow.

A case of human attack by the tigress at Dhikala was believed to be due to collective pressure of tourists and hunger. Since this tigress has litter and thus close approach of tourist disturb the animal prior to attacking natural prey. Finding food is difficult if disturbed by humans and during protecting its cubs. This might lead to the attack of the person when she encountered by chance.

Livestock attack leading to economic losses is probably the most important issue in the study area. My finding is based on the monitoring of incidents reported by villagers. Results clearly indicated that tiger's attacks on livestock are high and on humans are occasional. Findings of the study show that tiger is inflicting substantial loss to local people in and around buffer zone of the Corbett Tiger Reserve. Estimated annual economic loss due to livestock depredation is Rs. 2,333,350 year. Calculated annual economic loss due to livestock damage is Rs.

14056/village. It may be an acceptable figure at community level; however the loss is very high at individual level, who lost their livestock. Sometimes, tigers killed 4-5 livestock of a single household in a single day. This multiple killings by tigers ruin economic status of the family. Since, the majority of the population living in and around the tiger habitats is relatively poor and their livelihood depends on the livestock husbandry, the high proportion of losses due to livestock depredation by carnivores emerged as the main determinant in resolving tiger-human-conflict in the study area.

According to Finn (1929), livestock depredation is an aberrant behaviour of tiger when it becomes regular and obsessively habituated. But, this area has had a long standing problem of livestock depredation by tigers and livestock contributed 23% to the diet of tiger (Chapter 5). Livestock species, because of their reduced escape abilities compared to wild herbivores, are more prone to predation (Nowell & Jackson 1996). Livestock depredation in the area is not a recent phenomenon but frequency of the killing of livestock by carnivores has increased during the last two decades which coincides with the rising population of tiger in Corbett Tiger Reserve.

Despite the fact that villagers have been living with tigers for centuries, they do not take any preventive measures to reduce attacks of tiger on their livestock. They leave their cattle unattended to graze in the forest and if attended, not carefully overseeing their movement. Cattle left unattended to graze in forested areas become the dominant prey for carnivores in terms of available biomass (Schaller & Crawshaw 1980, Schaller 1983). Tigers killed more cow in comparison to buffalo because of two possible reasons, first, people living in hilly areas, prefer to rear cows in comparison to buffaloes as cows are more adaptable to graze in hilly terrains due to their small size and secondly, it was easy for tiger to handle a cow at the time of attack. This statement was also supported by injured livestock. More buffaloes were able to defend themselves from the tiger in comparison to cows which indicated that tigers find difficulty in handling the large prey species such as buffalo. Most of the cases of livestock depredation occurred when owner was not accompanying the livestock. Livestock is rarely accompanied by the owners during the day time and left free ranging to graze in the area. Care in herd attendance and active defence is totally lacking in the study area. Though the conflict is very high in CTR, people seem to give poor attention to their cattle.

Highest numbers of attack on livestock by tigers were recorded in monsoons (July, August, September and October). Patterson et al. (2004) have also reported similar trend in case of lion's predation on livestock in Tsavo National Park in Kenya. Heightened attack in rainy seasons may also be a result of increase in vegetation cover since, the rainfall in study area stimulated fast vegetative growth which provides cover to the predators to ambush prey. It might also be possible that during the rainy season, vegetative cover increases and predators move close to human settlements and chances of tigers encounter with livestock get increased. Another factor which contributed to the raise in attacks is less utilization of killed prey during the monsoon. It was found that during monsoon meat petrified rapidly and maggots develop soon on the carcass. However Chauhan (2005) reports high incidence of livestock attack in winter in Dudhwa National Park, Uttar Pradesh.

Tiger attacked averaged 9 cattle/week and this is considerably big loss to local people living in and around the CTR. High intensity of livestock depredation in Sanwalde bhavar, Dhela buffer and N. Jaspur forest blocks was because of the intensive pressure of livestock grazing in these forest blocks, which leads to decline in natural prey. These blocks also have the *Gujjar* settlements and they leave their livestock to graze during the night, which makes the livestock more vulnerable to carnivore attacks. Belghatti *gujjar* settlement located in the Sanwalde bhavar blocks has maximum number of livestock attacked by tigers because of their habit of grazing of livestock in the night.

Tigers attacked more livestock outside the boundary of CTR in comparison of inside. Corbett Tiger Reserve is surrounded by the reserved forests all over its boundary. These forested areas are managed under the different forest divisions but the protection is not as effective as Corbett Tiger Reserve. But these forested areas serve as corridors providing continuous habitat for the movement of tigers from Corbett and also have resident tigers. However, due to under marginal protection, these forested areas have degrading habitats and depleting quantities of natural prey base. These areas have high human and livestock population and are under the immense pressure of local people in terms of grazing of livestock, collection of fuelwood, fodder and NTFPs. Since the CTR has the highest density of tigers (Contractor 2007), it might be possible that sub-ordinate tigers moved to the adjoining forest in search of their range. These areas have high human settlement and livestock which, consequently leads to high encounter with tigers. The results are in accordance with study of Jaguars (Roosevelt 1926).

Compensation programmes increase tolerance of wildlife and promote more positive attitudes and support for conservation among local people who live closest to endangered and dangerous animal (Wagner et al. 1997). Currently these losses to local people are compensated by the Forest Department and Corbett Foundation (NGO). But, local people complain that the amount is low (50% of actual value); for smaller stock, the amount one pays in transport and medical certificate cost, to claim the compensation may negate the amount received. Another hindrance is the long bureaucratic procedure in securing compensation from Forest Department which keeps claimants waiting for over a year.

In CTR, the most important factor raising antipathy among local people towards the conservation of tigers is the conflict between tiger and human beings as a result of livestock depredation by tigers, which threaten the economic livelihoods of the local people. Since almost half of the tiger population lives outside protected areas, negative attitudes and perception by humans towards tiger is clearly the greatest imminent threat to the species survival. It is imperative to initiate work with local people and landscape level to maintain viable population. It is therefore necessary that tiger conservation should be addressed within the context of local people incentives, and appropriate social institution, to ensure the collective and not just individual interest in tiger conservation. Conservationists must pay attention to the feelings and incentives of local people and develop conservation initiatives with them. Producing guidelines for villagers on how to minimize conflict with tigers, through modification of tiger behaviour and livestock management practices, would be helpful in conservation of tigers. Reduction in livestock depredation by carnivores could be achieved by various means such as controlling predator (Stahl et al. 2001), exclusion of predator (Sillero-Zubivi & Laurenson 2001) or by improving livestock management (Breitenmoser et al. 2005). But control and exclusion of predator such as tigers rarely produce a long-term decline in losses (Landa et al. 1999, Stahl et al. 2001). Therefore, measures for improvement in the practice of livestock husbandry and life style of people sharing range with tigers could be implemented to reduce livestock depredation. Additionally, increasing tolerance of local people towards tigers could be optimal solution for the mitigation of tiger-human conflict in the areas such as Corbett Tiger Reserve.

5.1 Introduction

Food availability and its utilization is one of the most important factors influencing the distribution of free ranging animals. Formulation of any management strategy for the given species in question necessarily requires information on the food habits of the species (Martin 1955, Wilkins 1957). Prey population controls the distribution and population of predator but at the same time predator checks the drastic increase in the population of prey species and help in maintaining the equilibrium. Understanding of prey-predator dynamics is crucial for the conservation of top order predators and the functioning of the ecosystems. The knowledge of diet spectrum and feeding habits provides requisite information to understand complex relationship of predator and prey. It means understanding of feeding ecology of tiger is essential for the formulation of better management strategies for management and conservation of tiger within its distributional range.

Tiger is obligate predator preying upon the largest ungulates in all the ecosystems, in which they flourish (Seidensticker 1997). Large carnivores has play crucial role in shaping prey communities in the stable environments of tropical forests (Terborgh 1990). Field studies investigating prey selection have been scarce (Schaller 1967, Johnsingh 1983, Rabinowitz & Nottingham 1986, Karanth & Sunquist 1995, Biswas & Sankar 2002). Several recent studies investigated dietary spectrum of tiger (Koppikar & Sabnis 1979, Karanth & Sunquist 1995, Gogate & Chundawat 1997, Reza et al. 2001, Biswas & Sankar 2002, Bagchi et al. 2003) but there is little attention paid towards the predatory patterns of tigers in northern India, and documentation of this aspect is an important component of any effective conservation of plan for a highly endangered species like tiger, which inhabits a diverse array of forest ecosystems. Secondly, most of the studies were conducted in the core of protected areas free of human disturbances and provide no information on the contribution of livestock species in the diet of tiger and its consequence to local people. Therefore, scientific information on this aspect is vital for scientific understanding as well as for meeting conservation goals.

The objective of this chapter is to document the feeding ecology and dietary spectrum of tiger in buffer zone of the CTR, where tiger killed livestock of local people and livestock contributed significant portion in tiger diet. This aspect is more crucial to formulate the management strategies for the conservation of the tiger in the buffer zone of the CTR.

5.2 Methodology

There are various techniques to study the feeding habits of wild animals such as monitoring of kill, gut analysis, direct observation and scat analysis. Since, tiger is a solitary and secretive animal; it is difficult to have the direct observation on tiger. Two techniques were used to study feeding ecology of tiger viz. monitoring of tiger kills and scat analysis.

Since, buffer zone of the CTR was densely infested with Lantana (*Lantana camara)* and tiger normally drags its kills in dense cover of Lantana, which obstruct visibility and creates difficult situation to search the kill. That's why, in spite of equal effort, negligible number of wild prey kills were found, so my findings of tiger feeding ecology were based primarily on scat analysis and partially on monitoring of the livestock kill made by tiger.

Determining diet of large carnivore through monitoring of kills, is biased towards the big prey species because of unavailability of remains of small prey and also affected by the hunting, catching and feeding behavior of species involved (Karanth & Sunquist 1995). Therefore, scat analysis is the most appropriate method to know the food and feeding habits of carnivores and has been used by several investigators to study the diet spectrum of carnivores (Grobler & Wilson 1972, Muckerhirn & Eisenberg 1973, Smith

1978, Norton et al. 1986, Sathyakumar 1992, Chellam 1993, Mukherjee et al. 1994a, b, Karanth 1995, Easa 1995, Grassman 1997, Edgoankar & Chellam 1998, Singh et al. 1999, Khorozyan 2001, Biswas & Sankar 2002, Jethva 2002, Habib 2007).

5.2.1 Monitoring of kill

Data collection: The buffer zone (BZ) of the CTR and its surroundings were thoroughly searched to locate tiger kills. The monitoring of kill was biased towards livestock since wild prey was hard to trace in the dense cover of Lantana and livestock kills were reported by villagers. All the livestock kills were inspected to establish the identity of the predator involved and to know the different parameters of predator feeding habits. The predator was identified on the basis of pattern of feeding, pugmarks and other indirect signs. Mostly tiger would start feeding from the rump portion. The size of the victim also indicate the predator involved as the predation on various sized prey species is governed by the body weight of the predator (Karanth & Sunquist 1995). Data on predator species, and species killed health, weight, age and sex of victim and the place of incident were recorded at the time of inspection of each kill. Health of the victim was categorized into poor, average, good and very good while age was categorized into calf, sub-adult and adult. Weight of the victim was categorized into four categories as 50-150, >150-250, >250-350 and >350 kg. Data were also collected on vegetation type, cover condition, topography type, distance to human settlement, distance to water, portion and proportion of kill consumed, method of killing, excreta removed or not and the distance of carcass dragged by the predator.

Analysis: Data on type of species, age, sex, health, percent of consumption, portion and proportion consumed, method of killing, mode of feeding, different habitat parameters, collected at place of incident was summarized to deduce the information on the feeding habits of tiger.

5.2.2 Scat analysis

Data collection: The diet composition of tigers was studied through scat analysis. Scats were collected on all line transects and during random searches carried out on trails in different blocks. Road network of the buffer zone of the CTR was also searched regularly for the collection of scats. Precaution was taken to differentiate tiger scats from leopard scats as leopards were also found in the study area. The size and features of scats and the sign of scratch mark were used to differentiate tiger scats from leopard scats. Scats were collected in self-sealing polythene bags, which were marked with the date, season, predator, and the location with permanent marker. In addition, data on various habitat parameters were also collected. Fresh scats were dried before the bag was sealed. During the study period, 39 tiger scats in 2002-03, 206 tiger scats in 2005-06 and 174 tiger scats in 2006-07 were collected from in and around the buffer zone of the CTR.

Analysis: The dry scats were teased with forceps and crushed with the help of wooden stick. Presence of hooves, bones, claws, quills, feathers and other indigestible material present in the scat was also recorded in order to identify prey species. After that hairs were randomly picked from different part of the scat with the help of forceps and kept in the Xylol for 24 hours. Then hair sample was mounted in the DPX and examined carefully under the binocular microscope. Initially 50 hairs from 48 samples were analyzed for the standardization. It was found that analyzing 18 hairs could detect all the prey species found in the tiger scats. Then, for further analysis, 20 hairs were randomly picked from each scat of tiger. The characteristic of medullary patterns of the hair sample were then compared with the reference slide of mammalian hair samples. The prey composition of the tiger diet was extrapolated in terms of the frequency of occurrence of a prey in the scats (F_i) which was calculated as:

$$\mathbf{F_i = (n_i/N) \times 100}$$

Where, n_i is the number of scats in which the i_{th} species occur and N is the total number of scats analyzed.

Although the frequency of occurrence of prey species indicates how common a prey species is in the diet of the carnivore, percent occurrence provides a better indication of the relative contribution of the particular species in the diet of the carnivore (Ackerman et al. 1984). So the percent occurrence of a prey species was calculated as:

% Occurrence = (Occurrence of a species/Occurrence of total species) X 100

To determine the effect of effective sample size required to represent the entire range of prey species, 10 tiger scats chosen randomly and their content analyzed. This was continued until all 204 scats in the sample were analyzed. The cumulative frequency of occurrence of different prey species in the tiger scats over successive random draws was then assessed to infer effect of sample size on the final results.

Relative biomass and reconstruction of tiger's diet

Frequency of occurrence of identifiable prey species in carnivore scat do not provide a representative picture of the consumed proportion of different prey species when prey sizes are highly variable and can considerably distort the relative number of different prey species in carnivore diet and smaller prey species, having more hair per unit body weight produce more scats per unit prey weight consumed, leading to an overestimation of smaller prey species in the carnivore diet (Floyd et al. 1978, Ackerman et al. 1984). So frequency of occurrence of different prey species in the scats of tiger was converted to the relative biomass and number of different prey species consumed, which provide the actual selectivity pattern. Following the approaches used by several studies (Schaller 1967, Johnsingh 1983, Putman 1984, Karanth & Sunquist 1995, Biswas & Sankar 2002), the correction factor developed by Ackerman et al. (1984) from feeding trial on cougar *Felis concolor concolor* was selected to convert frequencies of occurrence into relative biomass and number of individuals killed. Therefore assuming that digestive system of tiger is comparable to that of cougar, the following regression equation was used to relates live weight of prey killed (*X*) to the weight of prey represented in one field collectable tiger scat *(Y)*:

$Y = 1.980+0.035X$
Where Y = kg of prey consumed per field collectable scat
X = average weight of an individual of a particular species

Above equation was used to estimate the average number of collectable scats produced by a given predator from an individual of each prey species ($\lambda i = X/Y$) and relative biomass and number of each prey killed (Ackerman et al. 1984). After applying the above correction factor, results of scat analysis provided unbiased estimates of proportion of even the smaller prey species.

The average weight (*X*) of individuals of wild prey species was taken from Karanth and Sunquist (1995), Biswas and Sankar (2002) and Khan et al. (1996) and that of domestic livestock from Schaller (1967). Calculation of *Y* gave an estimate of biomass consumed per collectable scat for each prey species consumed by tiger. Multiplication of *Y* with number of scat found to have a particular prey species gave the relative weight of each prey species consumed. These estimates of relative weight were used to estimate percent biomass contribution of different prey species to the tiger diet.

Analysis of prey selection

Selectivity for principal prey species was tested using χ^2 goodness-of-fit test (Zar 1999) based on null hypothesis of random or non selective prey killing by predator. Predation was selective in nature when proportion represented by potential prey species in scats differed from expected proportion in the community of prey species at a 95% level of significance ($p = 0.05$).

The program SCATMAN (developed by J.E. Hines & W.A. Link; Link & Karanth 1994) was utilized to calculate the expected proportion of prey species in scats. Density estimates of both individuals and groups of individuals of wild prey species was used to calculate expected scat frequencies based on the assumption of non-selective predation by tiger. Observed and expected proportions of prey species in the scats were then compared using G test (Zar 1984). Scats having more than one prey species were given equal weight to each species following Karanth and Sunquist (1995). If there was a pattern of overall prey selection, use of each prey species as calculated by the program inspected. Link and Karanth (1994) suggested that variability in the density estimates of each prey species and number of scats produced from a particular kill of any species is the potential source of inflation of type I error. Thus, program also incorporates the effect of such variability (Link & Karanth 1994) and reduces the inflation of type I error to produce an unbiased probability value. To overcome this problem parametric bootstrap procedure of the program for 1000 times suggested by Link and Karanth (1994) was also implemented.

Karanth and Sunquist (1995) used density of groups of individual to determine the selectivity in prey selection while the Biswas and Sankar (2002) used both density of individuals and groups to make conclusion about the selectivity in predation. Karanth and Sunquist (1995) reasoned that predation on a particular species is likely to be determined by groups of individuals which influences the encounter rates between prey and predator species in a forested ecosystem. According to Biswas and Sankar (2002), although density of groups affects encounter rates, group size would also be an important factor influencing the chance of sighting of prey by predator. Therefore, following Biswas and Sankar (2002), both the results from density of groups and individuals were used for understanding the predation pattern of tigers in the study area.

5.3 Results

5.3.1 Monitoring of Tiger kill

Technique of prey killing: Tiger mostly used the technique of strangulation for the killing of prey animal. Tiger bites on the neck and ruptures the neck vertebrae and prey animal dies because of suffocation. During the study, most of the prey species were killed by strangulation but in one case a tigress showed very abnormal hunting behavior. To find out the carcass of victim, I started to follow the drag marks from the original place of hunting site, but the drag mark was unusual, it was narrow than the normally found in the case of adult buffalo. Initially I thought that the tiger had dragged the victim. But when I found the victim, it seemed that tigress might had just paralyzed the buffalo by breaking both its hind legs and ran away because all the other cattle might have counter attacked the tigress. Buffalo moved only by two front legs and the hind legs were unable to support and dragged behind. After moving around 200 m, victim fell down on the ground and tigress started feeding on the live animal. This tigress was sub-adult and had also killed two calves of the buffalo in the same area. This indicates that the tigress was an inexperienced individual and not able to handle the big prey species like adult buffalo.

In cases, where tigress was accompanied by her cubs, it was seen that the marks of claws and canines were found on the various portions of body of the prey. This indicates that cubs were in the learning phase of killing of prey species and had no experience where to attack the prey species.

Mode of feeding: Tiger mostly start feeding from the hind (rump) portion of the victim but sometimes, during the dragging process when carcass entangled into some obstacle, tiger was forced to feed on the other portion too. Out of 223 cases, monitored during the study period, it was found that in 61.4% cases (n=138) tiger started feeding from the hind portion while in 1.8 % cases (n=4) tiger started feeding from the belly of the prey species.

In 21.1% of cases (n=47), tiger had consumed major portion of the carcass so it was not possible to knew the portion from which tiger start feeding. While in 9.4 % of cases (n=21) tiger did not feed on the victim because of some reasons and in 5.8% cases (n=13) it was not traceable the portion on which tiger had fed because the carcass was eaten by the scavengers.

Tiger separate gut portion and never mixed the content of intestine with flesh. Generally it is believed that tiger separate gut portion to decrease the weight of carcass so as to drag easily. But it is not true because, out of 223 cases, in 55.2% cases (n=123), it was found that predator dragged the victim without removing excreta but in these cases tiger fed only on the hind portion or sometimes cubs accompanied the tigress and they started feeding on the belly without separating the stomach. Cubs also dislocated different portions of the carcass and fed at different places close to the mother. So when tigress with her cubs feed on the prey animals, the bones of carcass were found scattered around the feeding place.

Kill hiding: Scavengers like wild boar, jackals, vultures and crows also feed on kills made by tiger. There is immense anthropogenic pressure and disturbance in the buffer zone of the CTR. To conserve its kills from scavengers and to avoid the disturbance, tiger drags the carcass into dense cover of vegetation. Sometimes tiger also covers the carcass with litter.

Composition of prey species: Out of 441 tiger kills monitored during the study, 413 were of livestock while 28 were of wild prey species. Tiger killed 159 cows, 126 buffaloes, 57 bullocks, 13 he-buffaloes, 24 cow calves, 32 buffalo calves and single individual of horse and mule each among livestock while preyed upon 12 chital, 8 sambar, 3 wild pig, 3 nilgai and single individual of muntjac and langur each. Monitoring of kills were biased towards the livestock because of certain reasons viz. inability to find out the wild kills in dense cover of lantana and lack of manpower. Among the wild prey species chital was most common prey species killed by tigers while among livestock cow was most commonly killed prey species. Tiger killed 240 individual of Cow (include cow, bullock and cow calf), 171 buffaloes (include buffalo, he-buffalo and buffalo calf) 12 chital, 8 sambar, 3 wild pig, 3 nilgai and one individual of muntjac and langur each (Fig. 5.1).

The composition of kills differed significantly between seasons (χ^2 = 78.77, d.f. = 3, P<0.001). There were 93 and 102 livestock kills during winter and summer season respectively. The number of prey killed by tigers increased substantially during monsoon (Fig. 5.2). Only 32 kills were recorded during post monsoon season. The pattern of prey killing by tigers differed significantly between sexes (χ^2 = 127.47, d.f. = 1, P<0.001). Tigers killed more female individuals of chital, cow and buffalo than expected by chance and lesser number of male individuals (Fig. 5.3).

The distribution of prey species killed by tigers differed significantly between different age categories (χ^2 = 302.65, d.f. = 2, P<0.001). Majority of the prey species killed by tiger comprised of adult individuals (71.95%), (Fig. 5.4). The prey species killed by tigers showed significant differences in terms of weight (χ^2 = 184.36, d.f. = 3, P<0.001) and health (χ^2 = 306.08, d.f. = 3 P<0.001) of the animal. Majority of the prey killed belonged to weight categories 50-150 and 150 to 250 kg and were found to be in good and average health categories (Figs. 5.5 and 5.6).

Factors such as type of vegetation, tree cover, shrub cover, topography, availability of water and distance to human habitation also had significant influence on the distribution and pattern of prey species killed by tiger. The number of prey killed by tigers differed significantly between vegetation types (χ^2 = 532.18, d.f. = 9, P<0.001). Significantly high number of kills (39.2%) was recorded in mixed vegetation type followed by plantation and reverine vegetation (Fig. 5.7).

The number of livestock killed differed significantly in relation to tree cover (χ^2 = 117.08, d.f. = 4, P<0.001) and shrub cover categories (χ^2= 117.36, d.f. = 4, P<0.001). While significantly high number of the kills were recorded in areas with 0-20% of tree and shrub cover, minimum number of kills were located in areas with >80% of tree cover and shrub cover (Fig. 5.8 and Fig. 5.9).

The distribution of prey species killed by tigers differed significantly viz- a-viz between different topography types (Fig. 5.10) (χ^2 = 630.43, d.f. = 3, P<0.001) and distance to water (χ^2 = 242.8, d. f. = 3, P< 0.001). There were higher numbers of prey kills on flat topography (76.19%) as compared to dissected (12.24), hilly (10.88%), and valley (0.68%). Majority (86.84%) of prey kills were located within a distance of 500 to 1000 m from water sources (Fig. 5.11).

Figure 5.12 provides the distribution of tiger kills in relation to distance to human settlements. The distribution of kills differed significantly among the different categories of distance of place of kill to the settlement (χ^2= 433.48, d. f. = 2, P<0.001). Majority (87.07%) of kills were located within a distance of 2 km from human habitation.

The tigers dragged their kills from the place of attack into some kind of cover because of human disturbance or to conserve the prey from the scavengers. Figure 5.13 provides distribution of kills in relation to distance to which tigers dragged their kills from the place at which the prey was killed. The distribution of kills differed significantly in relation to the distance dragged (χ^2= 736.18, d. f. = 3, P<0.001). Majority of the kills (82.81%) were found to have been dragged to a maximum distance of 200 m. The remaining kills were dragged beyond 200 m but to a maximum of 1000 m.

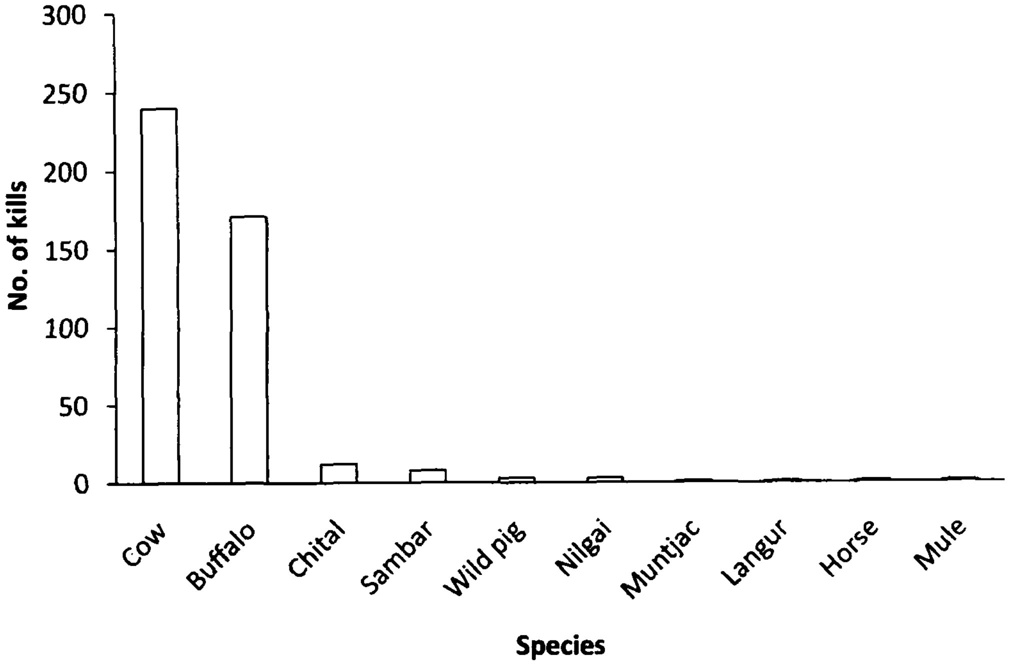


Figure 5.1: Number of different prey species killed by tiger

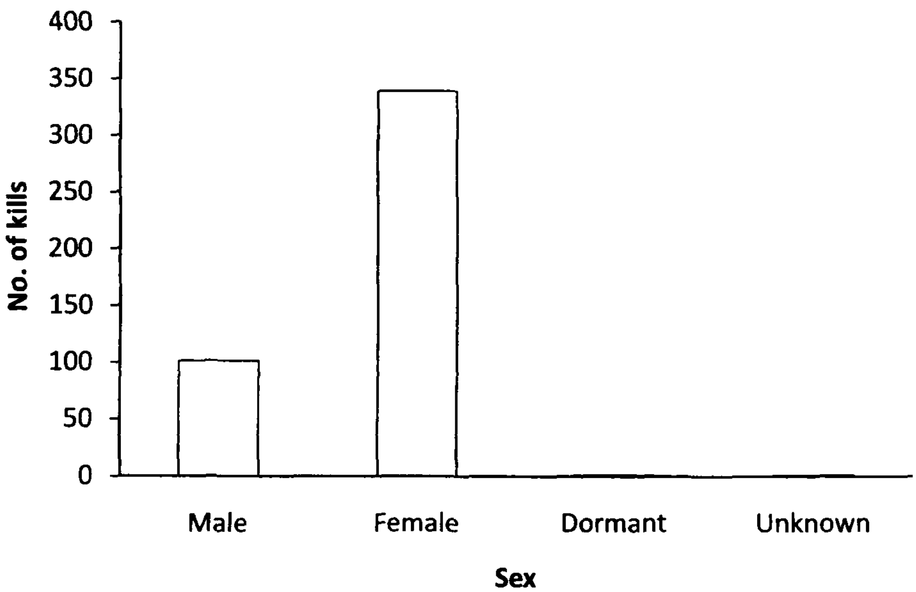


Figure 5.2: Distribution prey species killed by tiger in relation to sex of prey species

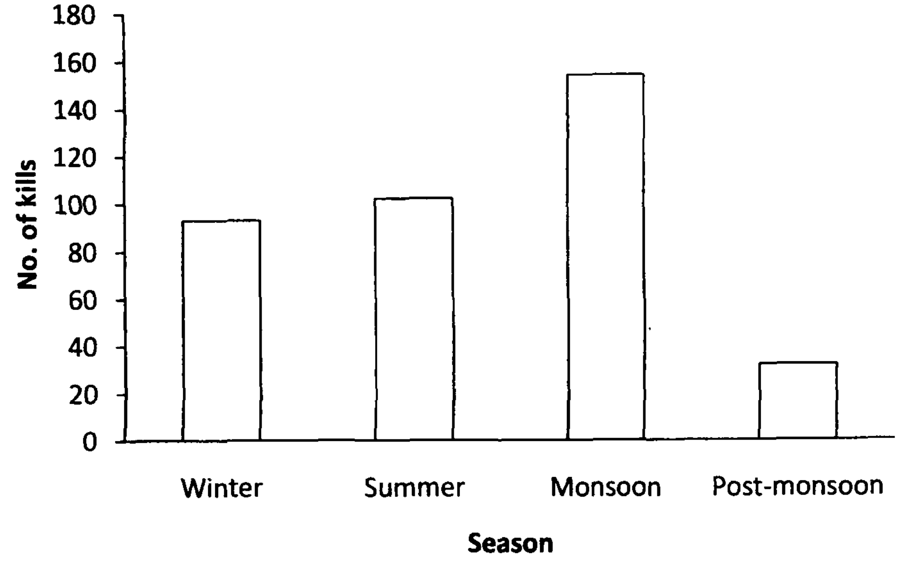


Figure 5.3: Distribution of prey killed by tiger in different season

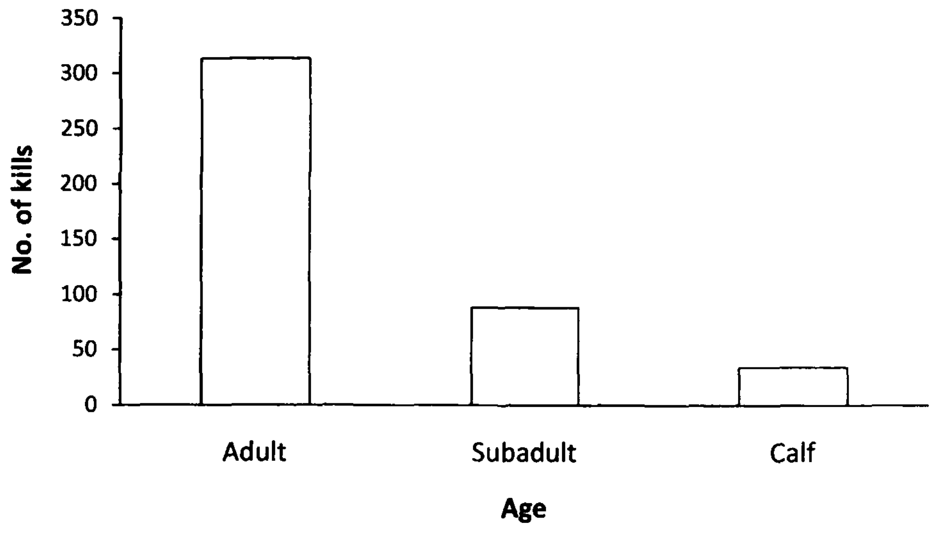


Figure 5.4: Distribution of prey species killed in relation to age of prey species

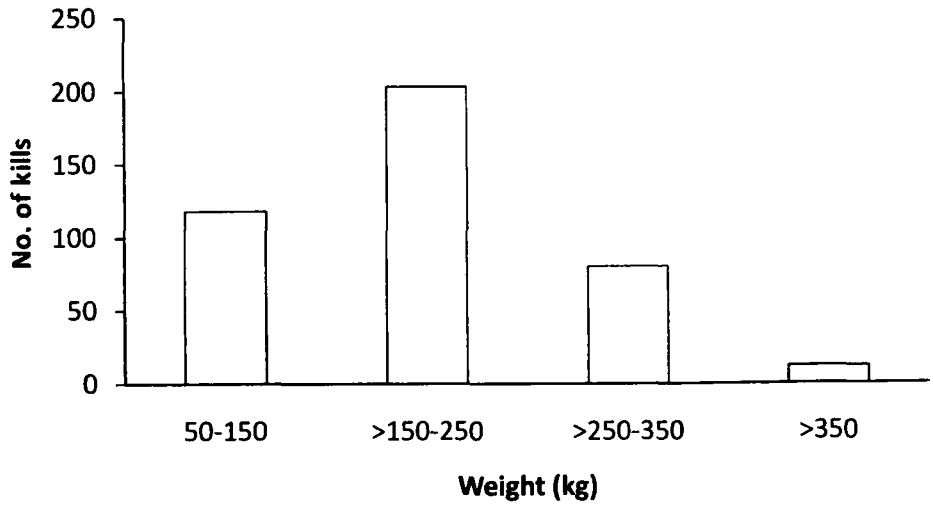


Figure 5.5: Number of prey species killed by tiger in relation to weight of prey species

Figure 5.6: Number of prey species killed by tiger in relation to health of prey species

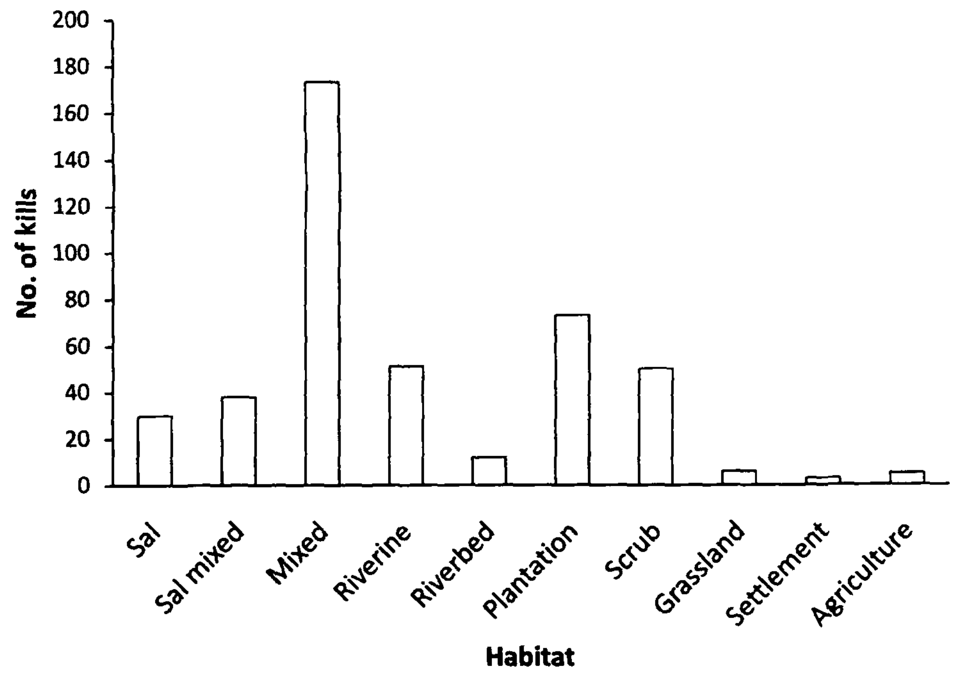


Figure 5.7: Number of prey species killed by tiger in different habitat types

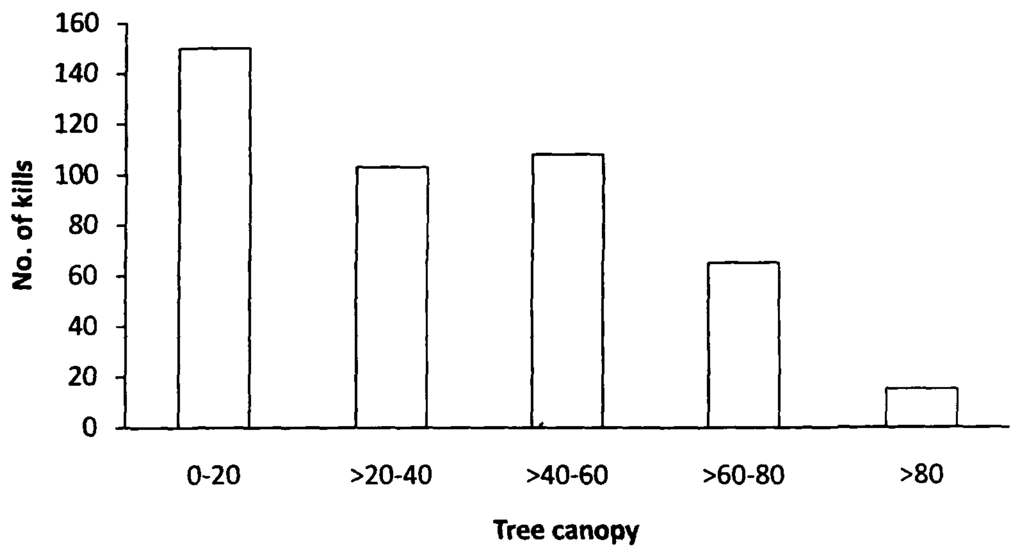


Figure 5.8: Distribution of prey species killed by tiger in relation to tree canopy

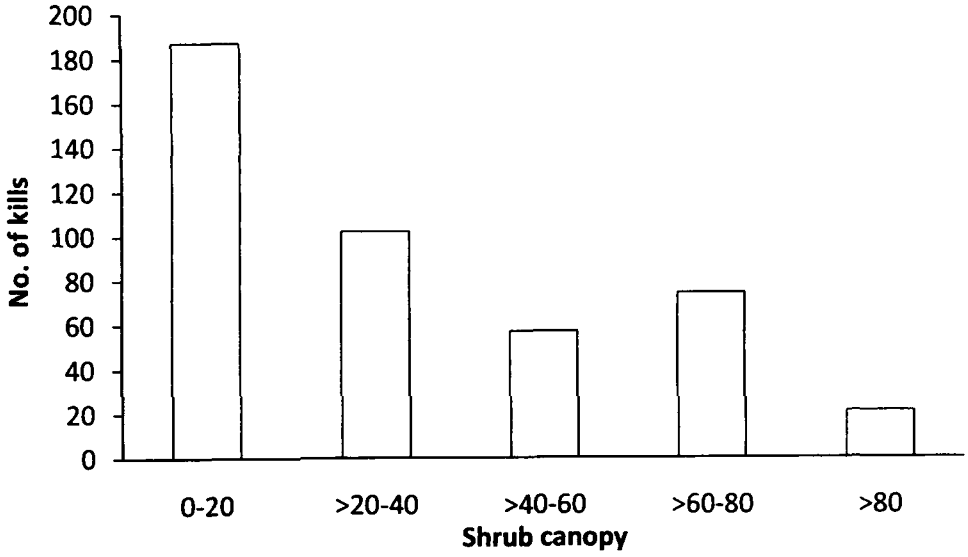


Figure 5.9: Distribution of prey species killed by tiger in relation to shrub canopy

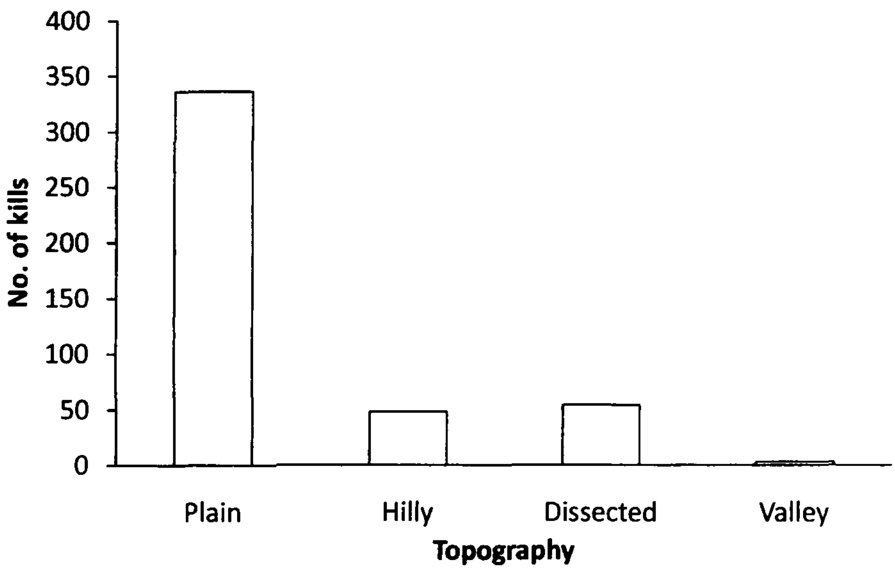


Figure 5.10: Number of prey species killed by tiger in different topography

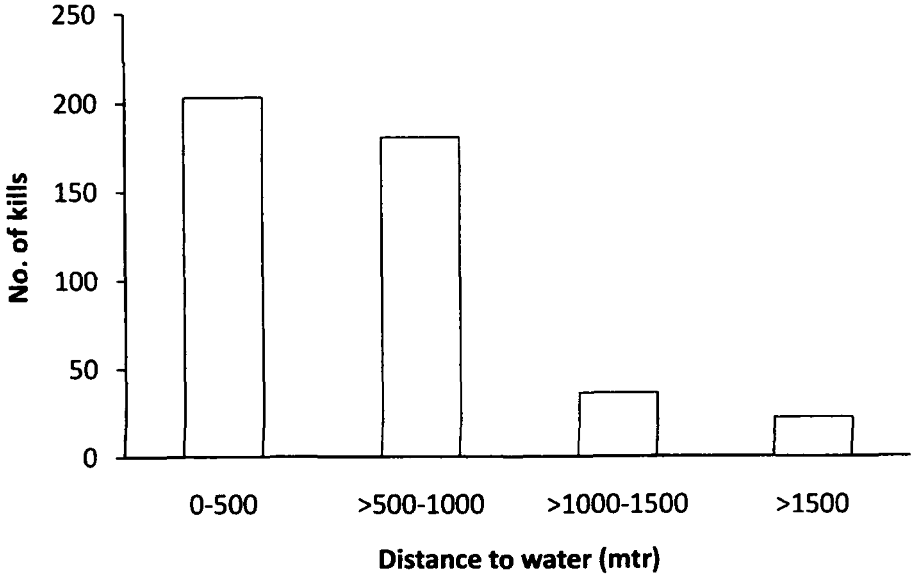


Figure 5.11: Distribution of prey species killed by tiger in relation to distance to water

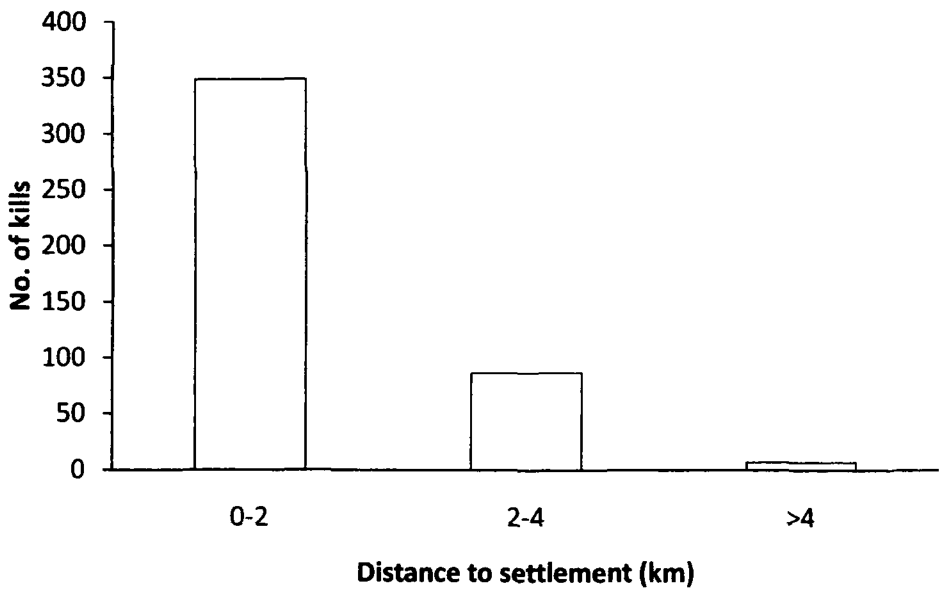


Figure 5.12: Number of prey species killed by tiger in relation to the distance to human settlement

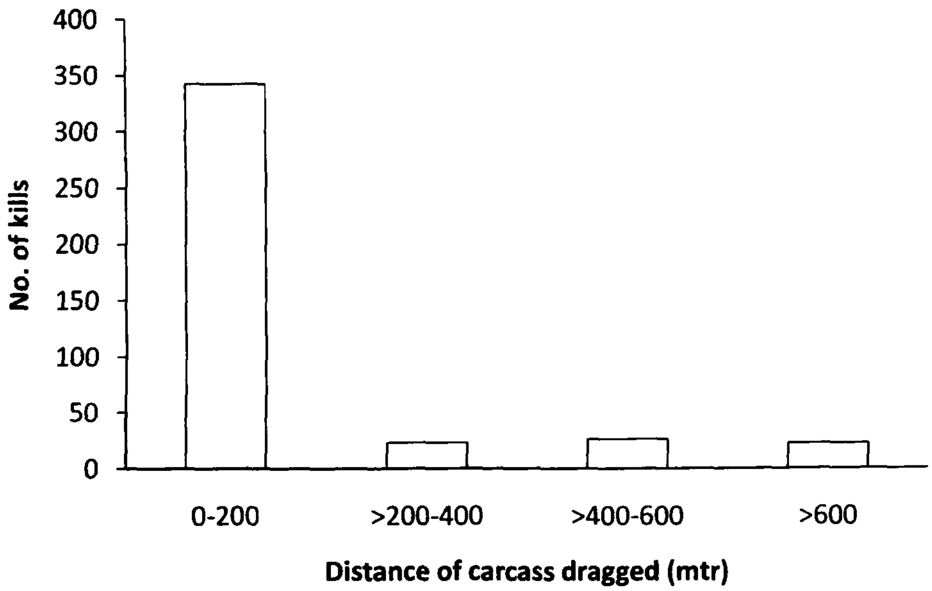


Figure 5.13: Distribution of prey species killed by tiger in relation to distance of carcass dragged by tiger

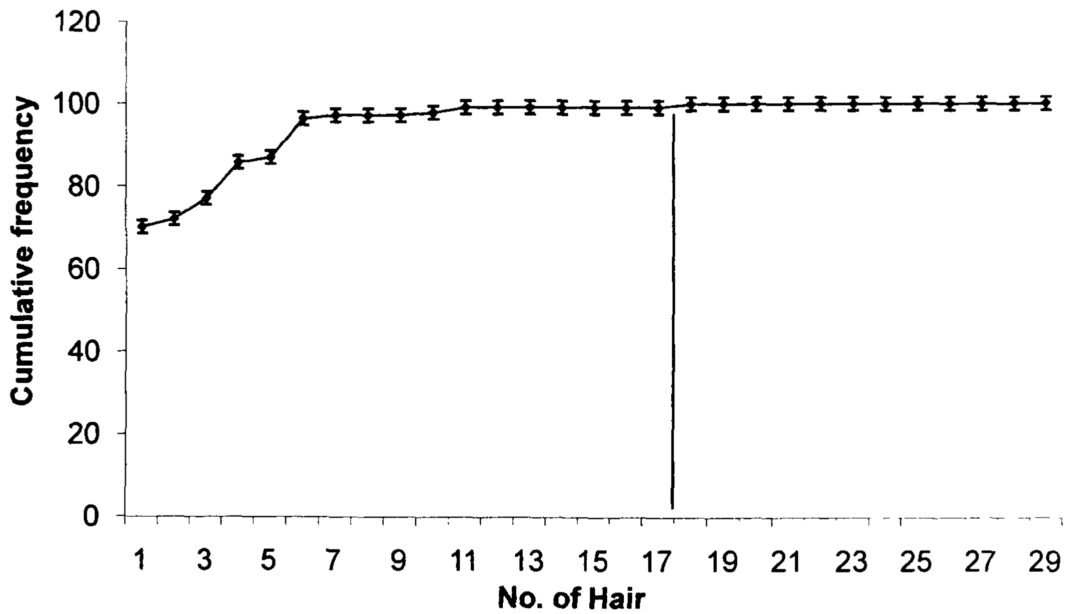


Figure 5.14: Standardization of tiger scats in the Corbett Tiger Reserve

5.3.2 Scat analysis

Sample size estimation for minimum number of hair/scat

Standardization of tiger scats, to know the minimum number of hair required to determine feeding habits of tigers in the study area, revealed that 95% species present in tiger scats, collected from the buffer zone of Corbett Tiger Reserve, can be detected by examining a minimum of 18 hairs whereas on examining 29 hairs from each scats, all the prey species in tiger scats can be detected (Fig. 5.14). It is concluded that analysis of 20 random hairs from each scat is sufficient to know the feeding habits of tiger in buffer zone of the CTR.

Sample size estimation for minimum number of scats

To estimate minimum number of scats, that required to be analyzed for a reliable representation of tiger diet, "Observation area-curve" was used. Percent occurrence of different prey species was calculated in increments of 10 scats from 204 scats collected during 2005-06. The "Observational area-curve" showed that major prey species of tiger (Except Jackal, which contributed less than 1% to tiger diet) were detected by analyzing 70 scat samples (Table 5.1). Variation in percent frequency of occurrence of principal prey species achieved an asymptote at 70 scats (Fig. 5.15).

A) Food habits of tiger (Pooled)

A total of 417 tiger scats were analyzed to determine the dietary spectrum of tiger in the buffer zone of Corbett Tiger Reserve. Out of these 417 scats, one scat (2002-03) had the hairs of leopard whereas, 3 scats (2005-06) had only hairs of tiger. Since tiger and leopard is not considered as potential prey for tiger, 4 scats having hairs of leopard and tiger were discarded from further analysis. Therefore results of further analysis were based on the 413 scats.

Table 5.1: Percent occurrence of prey species in tiger scats (2005-06, n= 204, Observation area curve –Odum & Kuenzler, 1965)

No. of scats	Chital	Sambar	Wild pig	Nilgai	Muntjac	Langur	Cow	Buffalo	Porcupine	UNI	Jackal	Hare	Rodent
10	50	40	0	10	10	10	10	20	0	20	0	0	0
20	55	40	0	5	10	15	10	10	0	20	0	0	5
30	50	36.67	6.67	13.33	6.67	13.33	6.67	6.67	0.00	13.33	0.00	0.00	3.33
40	50	32.50	7.50	12.50	5.00	15.00	5.00	10.00	0.00	12.50	0.00	0.00	5.00
50	50	32.00	10.00	10.00	4.00	12.00	6.00	10.00	0.00	12.00	0.00	0.00	6.00
60	51.67	33.33	8.33	8.33	5.00	10.00	6.67	8.33	0.00	11.67	0.00	0.00	6.67
70	**47.14**	**31.43**	**8.57**	**8.57**	**5.71**	**10.00**	**7.14**	**8.57**	**1.43**	**11.4**	**0.00**	**2.86**	**5.71**
80	46.25	33.75	8.75	7.50	7.50	8.75	6.25	8.75	1.25	11.25	0.00	2.50	5.00
90	48.89	34.44	8.89	6.67	6.67	8.89	5.56	10.00	1.11	10.00	0.00	3.33	5.56
100	48.00	36.00	9.00	6.00	6.00	9.00	5.00	9.00	1.00	9.00	0.00	3.00	5.00
110	47.27	32.73	9.09	5.45	5.45	8.18	7.27	9.09	0.91	8.18	0.00	2.73	4.55
120	48.33	30.83	8.33	5.00	5.00	7.50	7.50	10.00	0.83	7.50	0.00	2.50	4.17
130	48.46	33.08	7.69	5.38	4.62	6.92	6.92	10.77	0.77	7.69	0.00	2.31	3.85
140	49.29	31.43	8.57	6.43	4.29	6.43	7.14	10.00	0.71	7.14	0.00	2.14	3.57
150	50.00	30.67	8.00	6.00	4.00	6.00	8.67	10.00	0.67	7.33	0.00	2.00	3.33
160	50.00	30.63	7.50	6.25	3.75	5.63	10.00	10.00	0.63	7.50	0.00	1.88	3.13
170	51.76	30.00	7.65	6.47	3.53	5.29	9.41	10.00	0.59	7.65	0.00	1.76	2.94
180	50.56	28.89	9.44	7.22	3.33	5.00	9.44	11.11	1.11	7.78	0.56	1.67	2.78
190	51.58	29.47	8.95	7.37	3.16	4.74	9.47	10.53	1.05	7.89	0.53	1.58	2.63
200	51	29.00	8.50	7.50	3.00	4.50	9.00	11.00	1.00	7.50	1.00	1.50	2.50
204	50	28.92	9.31	7.35	2.94	4.41	9.31	10.78	0.98	7.35	0.98	1.47	2.45

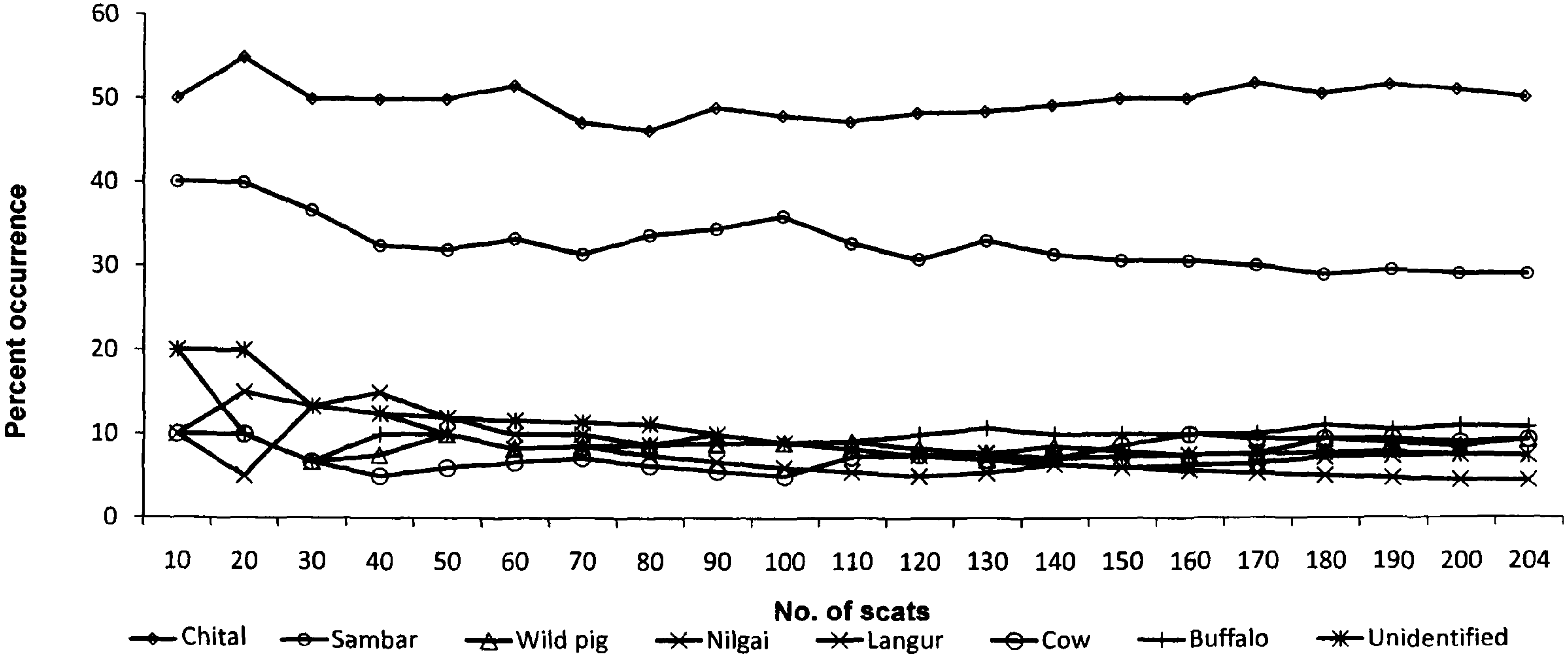


Figure 5.15: Estimation of minimum number of scats that need to be analyzed to study annual feeding habits of tiger in the buffer zone of the Corbett Tiger Reserve (n=204)

Out of 413 scats, 286 scats contained single prey species, 116 scats contained two prey species, and 10 scats contained three prey species whereas only one scat had four-prey species (Fig. 5.16). The overall diet diversity (H') of the tiger was 2.32. A total of 15 prey species were recorded in the diet of tiger in the buffer zone of the Corbett Tiger Reserve.

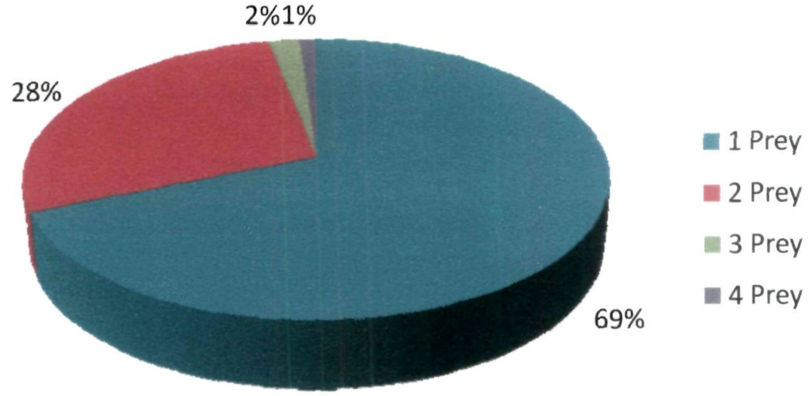


Figure 5.16: Proportion of scats in relation to number of prey detected in a single scat

Percent occurrence of different prey species in tiger scats, in the buffer zone of the Corbett Tiger Reserve, indicated that tiger is largely depend on large prey species (chital, sambar, wild pig, nilgai, cow and buffalo) which together contributed 89.3% of its diet in the buffer zone of the Corbett Tiger Reserve (Fig.5.17). Chital (40%) and sambar (23.2%) were contributed major portion of tiger's diet in the buffer zone of the CTR. Wild prey contributed 84.2% of tiger diet but livestock (both cow and buffalo) also contributed significant proportion (14.8%) in the tiger's diet in buffer zone of the Corbett Tiger Reserve.

Estimation of relative biomass contributed by different prey species to tiger diet by using equation developed by Ackerrman et al. (1984) gave a better assessment of the prey use than result obtained in terms of frequency of occurrence (Table 5.2). In terms of frequency of occurrence, chital contributed around two times (40%) more than sambar (23.2%) but its biomass (25.92%) contribution was less than biomass contributed by sambar (36.91%). The combined biomass contributed by major wild prey species, chital, sambar, wild pig, nilgai, muntjac and langur, to the tiger diet was 74.21%. Domestic livestock contributed 23.33% to the tiger diet.

Prey Selectivity

Result of prey selectivity is only relevant to wild prey species which contributed major portion of tiger's diet. Comparison of observed and expected frequency of occurrence of prey species, in tiger scats, indicated significant difference in utilization of prey species by tigers and rejected the hypothesis of non selective predation by tigers (χ^2 = 1040.57, d. f. = 14, P< 0.01). Sambar, nilgai and wild pig were found to be utilized more than their availability by tigers in the study area whereas langur was found to be utilized less than their availability, when both group and individual density was used to calculate expected proportion of scats (Fig. 5.18). Chital was found to be utilized less than its availabilty in case of individual density whereas utilized more than its availability in case when group density was use to calculate expected propotion of scats. But in case of muntjac, it was found to be eaten in according to its availability when individual density was used to calculate expected proportion of scats but utilized less than its availability when group density was used to calculate expected proportion of scats (Fig. 5.18).

Tiger was also found to be eaten bones and hooves of fawn of ungulate species and in 10 tiger scats bones of small prey and hooves of chital and sambar fawn, each in four scats, were detected. In some scats undigested grass species were also found. It might be a possible that tiger had eaten grasses when they had any digestive problem.

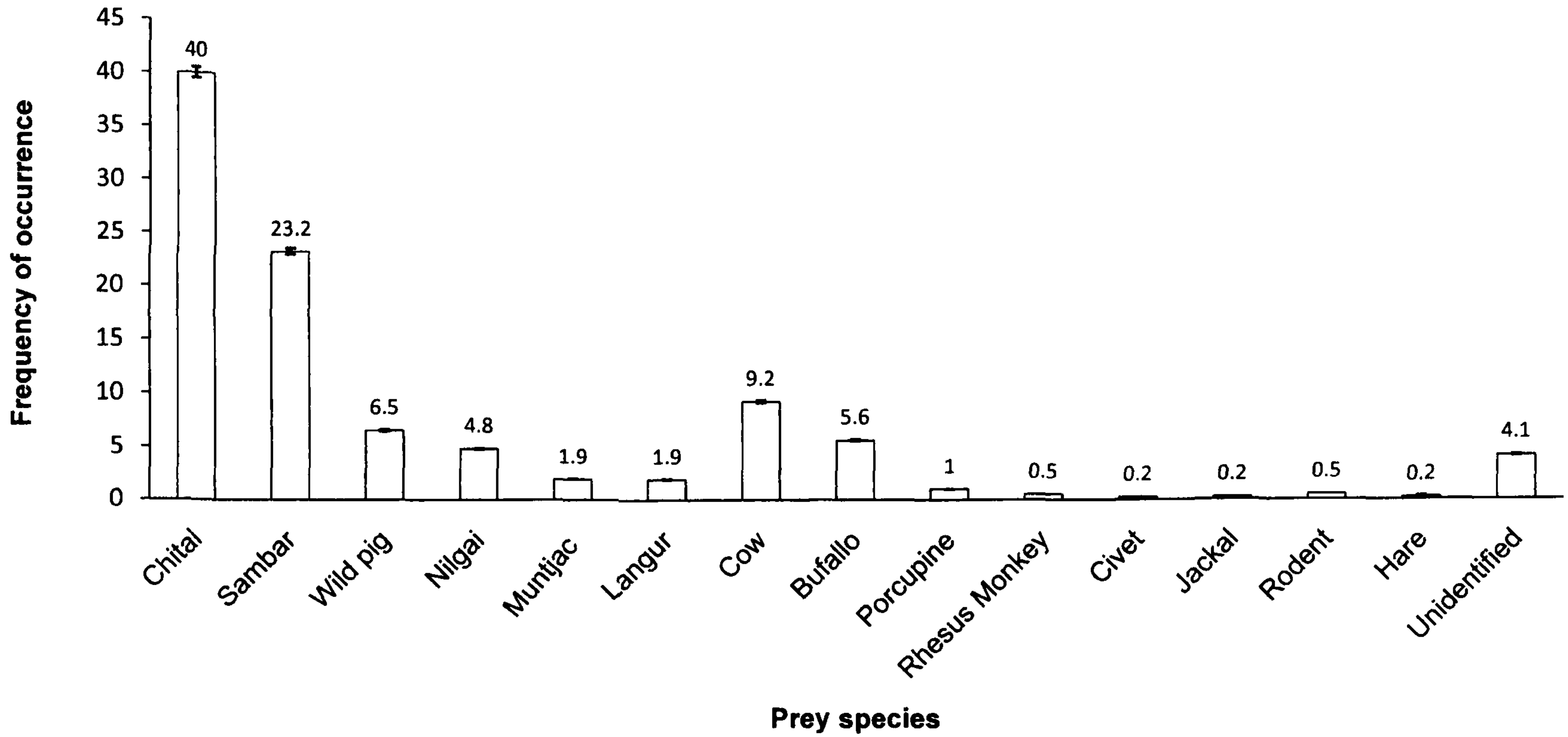


Figure 5.17: Food habits of the tiger in buffer zone of the Corbett Tiger reserve (Pooled). Error bars show 95% bootstrap confidence interval (n=413)

Table 5.2: Composition of tiger scats (n=413) together with estimated relative biomass and number of prey consumed

Prey species	Weight of animal	% Relative estimated	Collectable scat/kill	Biomass/ 100 scat (Kg)	% Biomass eaten	No. of individual eaten/100 scat	Ratio of number of individual
Chital	55	39.95	14.08	156.01	25.92	2.84	1
Sambar	212	23.25	22.55	218.50	36.31	1.03	0.36
Wild pig	38	6.54	11.48	21.64	3.60	0.57	0.20
Nilgai	184	4.84	21.85	40.78	6.78	0.22	0.08
Muntjac	20	1.94	7.46	5.19	0.86	0.26	0.09
Langur	9	1.94	3.92	4.45	0.74	0.49	0.17
Cow	180	9.20	21.74	76.18	12.66	0.42	0.15
Buffalo	273	5.57	23.67	64.24	10.67	0.24	0.08
Porcupine	14	0.97	5.67	2.39	0.40	0.17	0.06
Rhesus	4	0.48	1.89	1.03	0.17	0.26	0.09
Unidentified	5	4.12	2.32	8.87	1.47	1.77	0.63
Civet	3	0.24	1.44	0.51	0.08	0.17	0.06
Jackal	10	0.24	4.29	0.56	0.09	0.06	0.02
Rodent	2	0.48	0.98	0.99	0.17	0.50	0.18
Hare	2	0.24	0.98	0.50	0.08	0.25	0.09

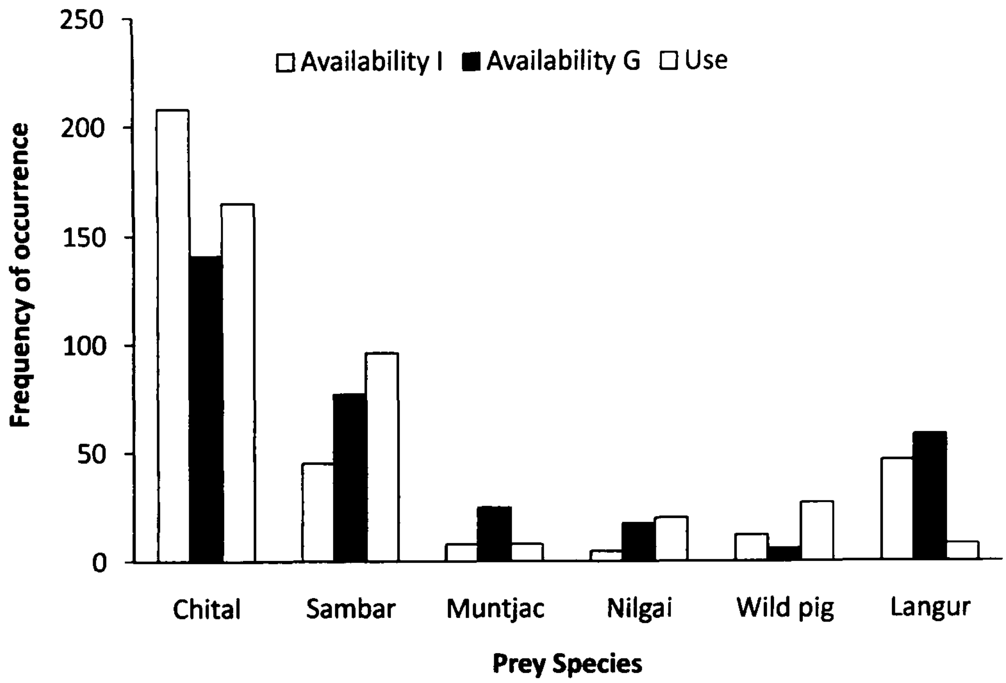


Figure 5.18: Comparison of observed and expected proportions of prey use in scats based on individual and group densities of prey species of tiger in the buffer zone of the Corbett Tiger Reserve. **Availability I, Availability G**, expected proportions of prey species in tiger scats calculated from density of individual and group of prey species respectively

Winter

Out of 289 scats, 210 scats had single prey species, 75 scats contained two prey species, and 3 scats contained three prey species while only one scat had four-prey species (Fig. 5.19). The overall diet diversity (H') of tiger in winter was 1.9. A total of 12 prey species were recorded in the diet of tiger in winter.

Percent occurrence of different prey species in tiger scats in buffer zone of the Corbett Tiger Reserve indicated that tiger in winter is primarily depend on the large prey species (chital, sambar, wild pig, nilgai, cow and buffalo) which together contributed 92.3% of its diet in winter (Fig. 5.20). Chital

41.4%) and sambar (23.4%) were contributed major portion of tiger's diet in winter. Wild prey contributed 83.9% of tiger diet but livestock (both cow and buffalo) also contributed significant proportion (16.1%) in the tiger's diet in winter.

Estimation of relative biomass contributed by different prey species to tiger diet is provided in Table 5.3. In terms of frequency of occurrence, in tiger's scats, chital contributed around twice (41.4%) to sambar (23.4%) but its biomass contribution was less than to biomass contributed by sambar. The combined biomass contributed by chital, sambar, wild pig, nilgai, muntjac, and langur to the tiger's diet was 72.9%. Domestic livestock contributed 24.8% to the tiger's diet.

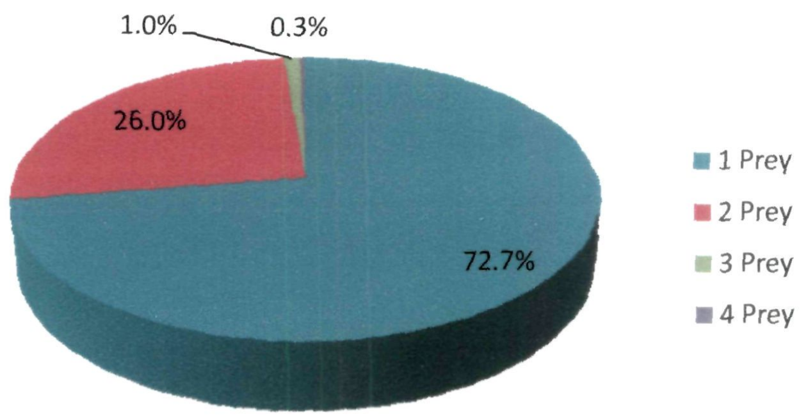


Figure 5.19: Proportion of scats in relation to number of prey detected in a single scat (winter)

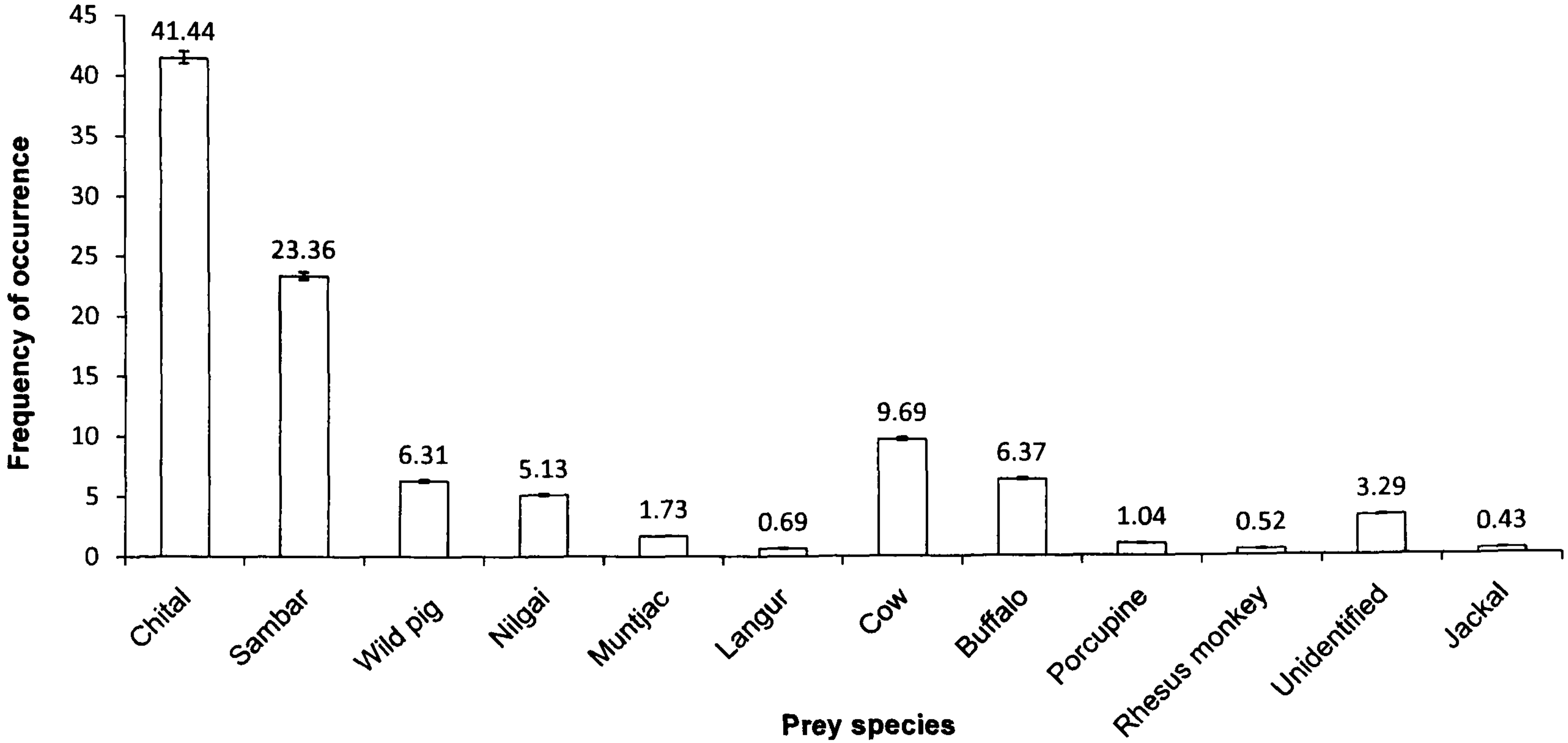


Figure 5.20: Food habits of the tiger in buffer zone of the Corbett Tiger Reserve. Error bars show 95% bootstrap confidence interval (n= 289)

Prey Selectivity

Comparison of observed and expected frequency of occurrence of prey species, in tigers scats, indicated significant difference in utilization of prey species by tigers and rejected the hypothesis of non selective predation by tigers in winter (χ^2 = 570.3, d. f. = 11, P< 0.01). Comparison of observed and expected proportions of prey species (wild species) in tigers scats, based on their individual density and group density in survey area, indicated the selection of prey species by tigers in winter. When individual density was used to calculate expected proportion of scat, sambar, wild pig and nilgai were found to be preyed more than their availability in the study area whereas chital, muntjac and langur were utilized less than their availability in winter (Fig. 3.21). But when group density of prey species was used to calculate expected proportion of scats, chital, sambar, wild pig and nilgai were found to be utilized more than their availability whereas muntjac and langur were found to be utilized less than their availability (Fig. 5.21).

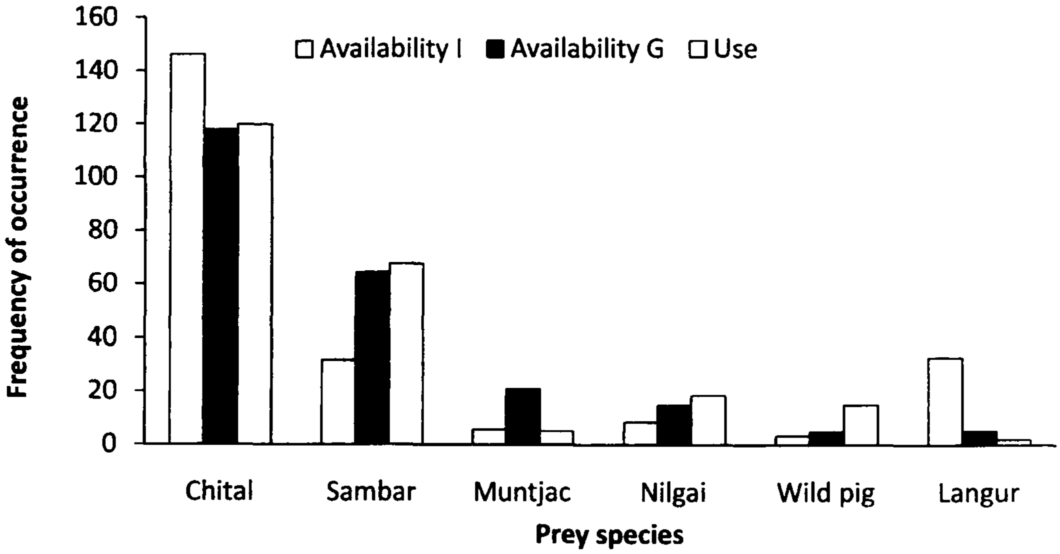


Figure 5.21: Comparison of observed and expected proportions of prey use in scats based on individual and group densities of prey species of tiger in buffer zone of the Corbett Tiger Reserve (winter). **Availability I, Availability G**, expected proportions of prey species in tiger scats calculated from density of individual and group of prey species, respectively

Table 5.3: Composition of tiger scats (n=289) together with estimated relative biomass and number of prey consumed (winter)

Animal	Weight of animal	% Relative estimated bulk	Collectable scat/kill	Biomass/ 100 scat (Kg)	% Biomass eaten	No. of individual eaten/100 scat	Ratio of number of individual eaten
Chital	55	41.44	14.08	161.81	26.12	2.94	1.00
Sambar	212	23.36	22.55	219.55	35.44	1.04	0.35
Wild pig	38	6.31	11.48	20.90	3.37	0.55	0.19
Nilgai	184	5.13	21.85	43.22	6.98	0.23	0.08
Muntjac	20	1.73	7.46	4.64	0.75	0.23	0.08
Langur	9	0.69	3.92	1.59	0.26	0.18	0.06
Cow	180	9.69	21.74	80.22	12.95	0.45	0.15
Buffalo	273	6.37	23.67	73.50	11.86	0.27	0.09
Porcupine	14	1.04	5.67	2.56	0.41	0.18	0.06
Rhesus monkey	4	0.52	1.89	1.10	0.18	0.28	0.09
Unidentified	5	3.29	2.32	7.08	1.14	1.42	0.48
Jackal	5	0.43	2.32	0.93	0.15	0.19	0.06

Summer

Out of 124 scats, 76 scats had single prey species, 40 scats contained two prey species, and 8 scats contained three prey species (Fig. 5.22). The overall diet diversity (H′) of tiger in summer was 2.5. A total of 13 prey species were recorded in the diet of tiger in summer.

Percent occurrence of different prey species in tiger scats, in buffer zone of Corbett Tiger Reserve, indicated that tiger is largely depend on the large prey species (chital, sambar, wild pig, nilgai, cow and buffalo) which together contributed 82.4% of its diet in summer (Fig. 5.23). Chital (36.1%) and sambar (23.3%) contributed major portion of tiger diet in summer. Wild prey contributed 88.5% of tiger's diet but livestock (both cow and buffalo) also contributed significant proportion (11.5%) in the tiger's diet in summer.

Estimation of relative biomass contributed by different prey species to tiger diet in summer is provided in Table 5.4. In terms of frequency of occurrence in scats, chital contributed around twice (36.1%) to sambar (23.3%) but its biomass contribution was less than to biomass contributed by sambar. The combined biomass contributed by chital, sambar, wild pig, nilgai, muntjac and langur to the tiger diet was 70.8%. Domestic livestock contributed 17.2% to the tiger diet in summer.

Prey Selectivity

Comparison of observed and expected frequency of occurrence of prey species in tigers scats indicated significant difference in utilization of prey species by tigers and rejected the hypothesis of non selective predation by tigers in summer ($\chi^2 \approx 233.17$, d. f. = 13, $P < 0.01$). Comparison of observed and expected proportions of prey species (wild prey) in tigers scats based on their individual density and group density in survey area indicated the selection of prey species by tigers in summer and indicated preference or avoidance of prey type by tigers. In case, when individual density of prey species was utilized to calculate expected proportion of scats, sambar, wild pig and nilgai were found to be utilized more than their availability whereas chital, muntjac and langur were found to be utilized less than their availability in summer (Fig. 3.24).

But when group density of prey species was used to calculate expected proportion of scats, sambar, wild pig and nilgai were found to be utilized more than their availability whereas chital, and muntjac were found to be utilized less than their availability and langur was found to be utilized according to its availability in the study area (Fig. 5.24).

Seasonal variation in composition of tiger's diet

Two way analysis of variance with seasons and prey species as main factor showed that there was no significance difference in occurrence of prey species in the diet of tiger (F= 1.29E-06, df = 2, 24, P= 0.99). However species were differently eaten during seasons (F= 226.72, df= 14, 14, P= 3.66E-11).

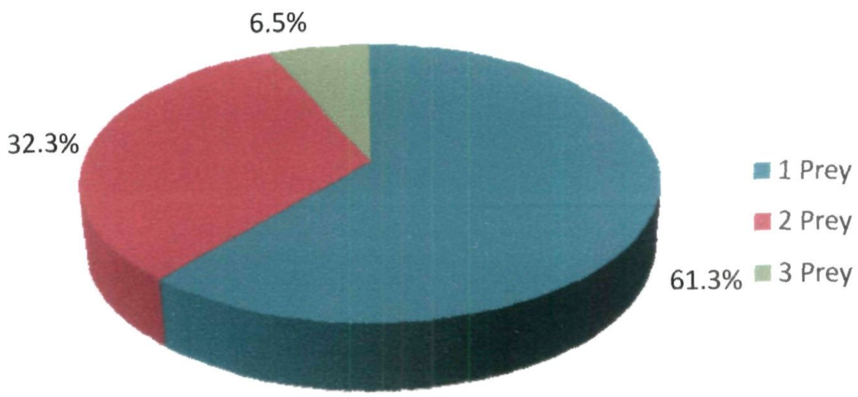


Figure 5.22: Proportion of scats in relation to number of prey detected in a single scat (summer)

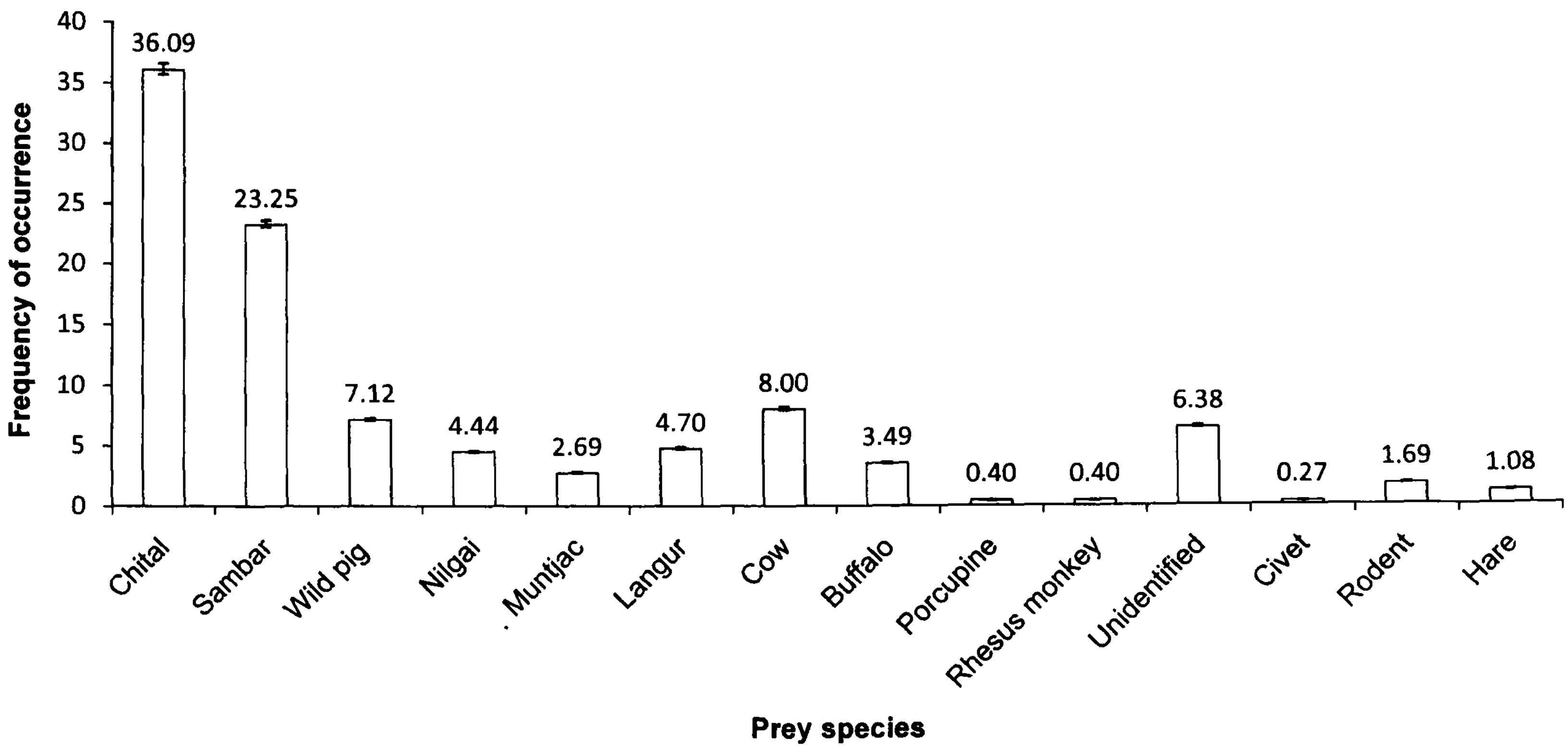


Figure 5.23: Food habits of tiger in buffer zone of the Corbett Tiger Reserve (summer). Error bars show 95% bootstrap confidence interval (n= 124)

Table 5.4: Composition of tiger scats (n=124) together with estimated relative biomass and number of prey consumed in buffer zone of the Corbett Tiger Reserve (summer)

Prey Species	Weight of animal	% Relative estimated bulk	Collectable scat/kill	Biomass/100 scat (kg)	% Biomass eaten	No. of individual eaten/100	Ratio of number of individual eaten
Chital	55	36.09	14.08	140.92	22.75	2.56	1.00
Sambar	212	23.25	22.55	218.57	35.28	1.03	0.40
Wild pig	38	7.12	11.48	23.58	3.81	0.62	0.24
Nilgai	184	4.44	21.85	37.35	6.03	0.20	0.08
Muntjac	20	2.69	7.46	7.20	1.16	0.36	0.14
Langur	9	4.70	3.92	10.79	1.74	1.20	0.47
Cow	180	8.00	21.74	66.21	10.69	0.37	0.14
Buffalo	273	3.49	23.67	40.31	6.51	0.15	0.06
Porcupine	14	0.40	5.67	1.00	0.16	0.07	0.03
Rhesus	4	0.40	1.89	0.85	0.14	0.21	0.08
Unidentified	5	6.38	2.32	13.76	2.22	2.75	1.07
Civet	3	0.27	1.44	0.56	0.09	0.19	0.07
Rodent	2	1.68	0.98	3.44	0.56	1.72	0.67
Hare	2	1.08	0.98	2.20	0.36	1.10	0.43

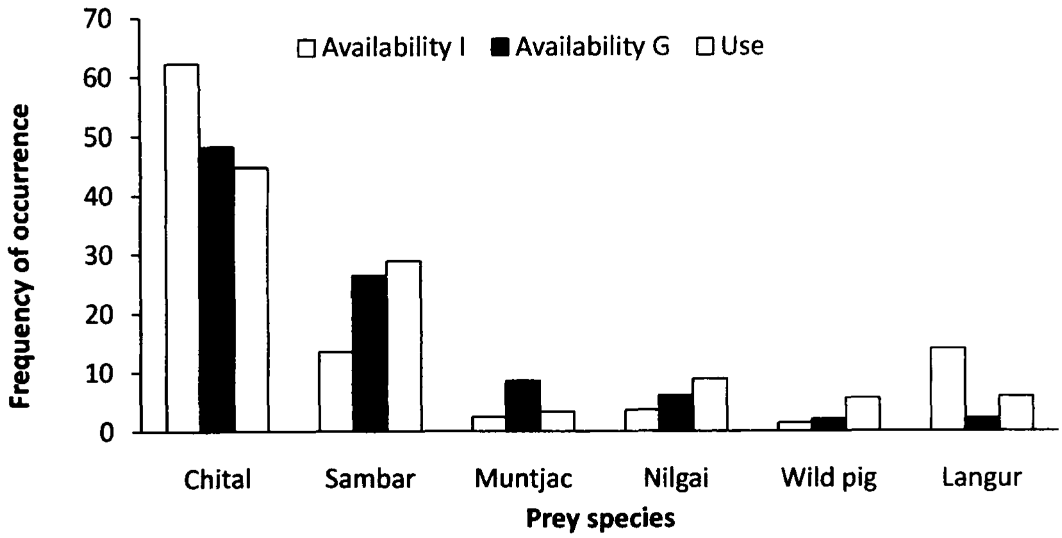


Figure 5.24: Comparison of observed and expected proportions of prey use in scats based on individual and group densities of prey species of tiger in the buffer zone of the Corbett Tiger Reserve. **Availability I, Availability G**, expected proportions of prey species in tiger scats calculated from density of individual and group of prey species respectively

(B) Food habits of tiger (2002-03)

Out of 39 scats analyzed during 2002-03, one scat had the hairs of leopard, so the result of diet analysis was based on the 38 scats. Out of 38 scats, 29 scats contained single prey species, 8 scats contained two prey species whereas only one scats contained three prey species (Fig. 5.25). The overall diet diversity (H') of the tiger in 2002-03 was 1.38. A total of 6 prey species were recorded in the diet of tiger in buffer zone of the CTR during 2002-03.

Percent occurrence of different prey species in tiger scats, in buffer zone of the Corbett Tiger Reserve in 2002-03, indicated that tiger is largely depend on the large prey species (chital, sambar, cow and buffalo) which together contributed 78.9% of its diet during 2002-03 (Fig. 5.26). Chital (50%) and sambar (18.4%) both were contributed major portion of tiger diet in 2002-03. Wild prey contributed 89.5% of tiger's diet but livestock (both cow and buffalo) also contributed significant proportion (10.5%) in the tiger's diet in 2002-03 (Fig. 5.26).

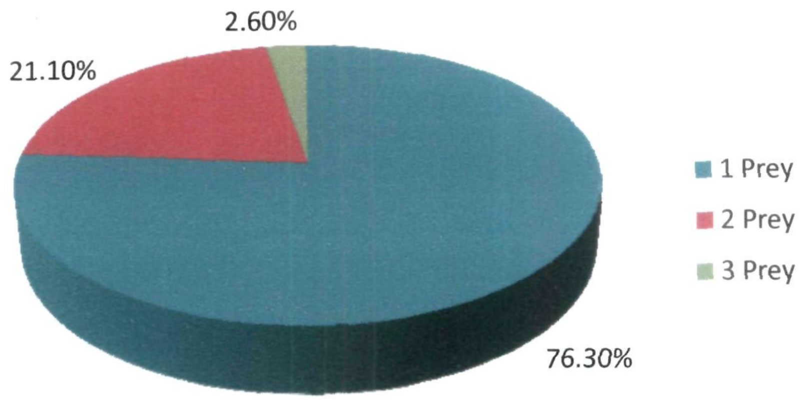


Figure 5.25: Proportion of scats in relation to number of prey detected in a single scat (2002-03)

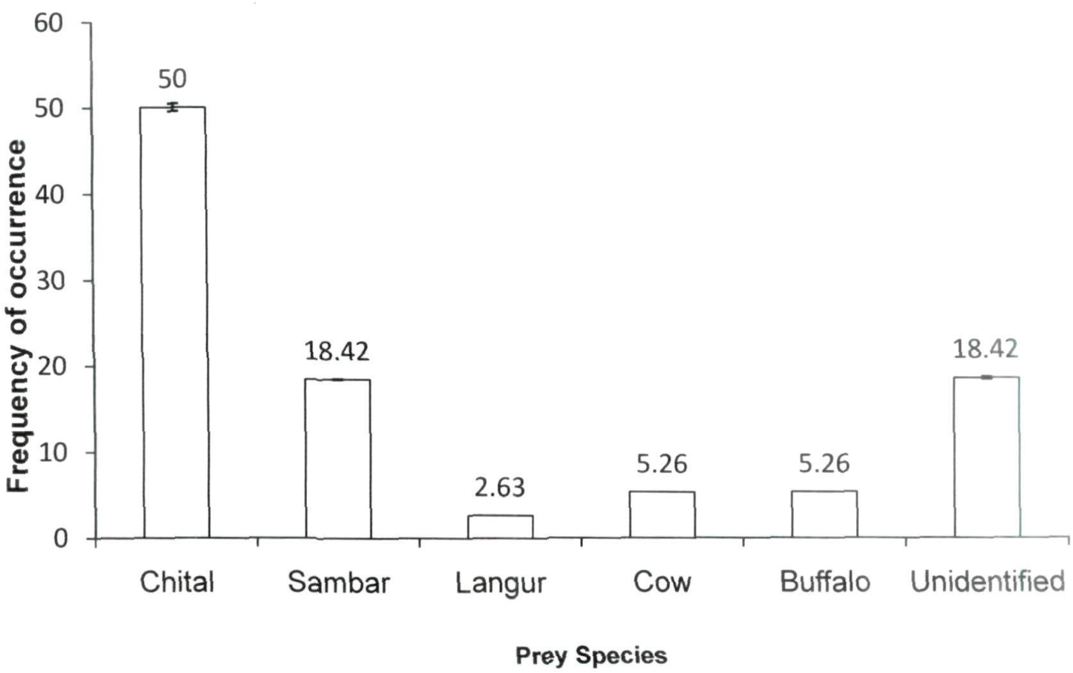


Figure 5.26: Food habits of the tiger in buffer zone of the Corbett Tiger Reserve (2002-03). Error bars show 95% bootstrap confidence interval (n=38).

Table 5.5 : Composition of tiger scats (n=38), together with estimated relative biomass and number of prey consumed in buffer zone of the Corbett Tiger Reserve (2002-03)

Prey Species	Weight of animal	% Relative estimated bulk	Collectable scat/kill	Biomass/ 100 scat (Kg)	% Biomass eaten	No. of individual eaten/100 scat	Ratio of number of individual eaten
Chital	55	50	14.08	195.25	37.66	3.55	1.00
Sambar	212	18.42	22.55	173.16	36.76	0.82	0.23
Langur	9	2.63	3.92	6.04	1.28	0.67	0.19
Cow	180	5.26	21.74	43.58	9.25	0.24	0.07
Buffalo	273	5.26	23.67	60.71	12.89	0.22	0.06
Unidentified	5	18.42	2.32	39.70	8.43	7.94	2.24

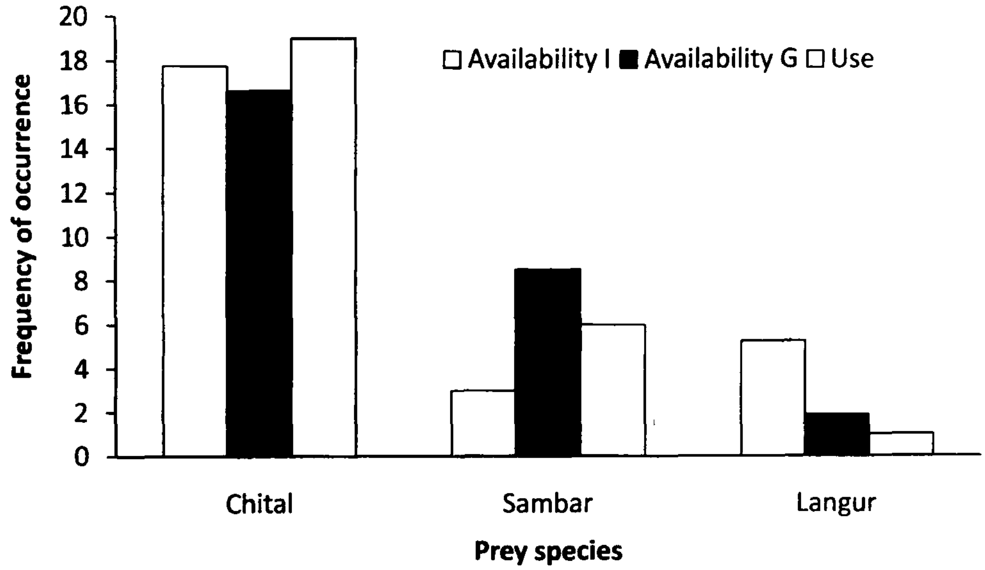


Figure 5.27: Comparison of observed and expected proportions of prey use in scats based on individual and group densities of prey species of tiger in buffer zone of the Corbett Tiger Reserve. **Availability I, Availability G**, expected proportions of prey species in tiger scats calculated from density of individual and group of prey species respectively.

Estimation of relative biomass contributed by different prey species to tiger diet in 2002-03 is provided in Table 5.5. In terms of frequency of occurrence, in tiger scats, chital contributed around three times (50%) more than sambar (18.42%) but its biomass contribution was equal to biomass contributed by sambar. The combined biomass contributed by chital, sambar and langur to the tiger's diet was 75.7%. Domestic livestock contributed 22.1% to the tiger diet.

Prey Selectivity

Comparison of observed and expected frequency of occurrence of prey species in tigers scats indicated significant difference in utilization of prey species by tigers and rejected the hypothesis of non selective predation by tigers in 2002-03 (χ^2 = 36.23, d. f. = 5, P< 0.01). Comparison of observed and expected proportions of prey species (wild prey) in tigers scats based on their individuals density and group density in survey area indicated the selection of prey species and pointed preference or avoidance of prey species by tigers in 2002-03. Sambar was found to be used more than its availability whereas chital and langur both were found to be utilized less than their availability by tiger, when both individual density and group density was used to calculate expected proportion of scats (Fig. 5.27).

(C) Food habits of tiger (2005-06)

Out of 204 tiger scats analyzed for 2005-06, 3 scats had only hairs of tiger while the other 5 scats had single hair of tiger with hairs of other prey species. Five scats having single hair of tiger might be contaminated during the feeding process while 3 scats having only the hairs of tiger were discarded from the further analysis of data to infer further results since tiger was not included as prey. So the results of diet composition of tiger were based on 201 scats only. Out of 201 scats, 137 scats contained single prey species, 56 scats contained two prey species, and 7 scats contained three prey species while only one scat had four-prey species (Fig. 5.28). The overall diet diversity (H') of tiger during 2005-06 was 2.26. A total of 13 prey species were recorded in the diet of tiger during 2005-2006.

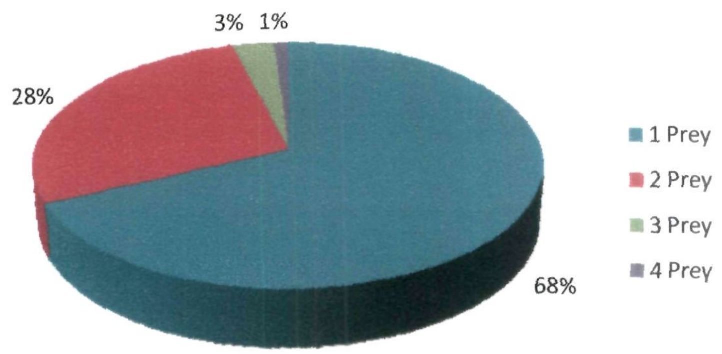


Figure 5.28: Proportion of scats in relation to number of prey detected in a single scat (2005-06)

Percent occurrence of different prey species in tiger scats, in buffer zone of the Corbett Tiger Reserve, indicated that large prey species (chital, sambar, wild pig, nilgai, cow and buffalo) were found to be major prey species in tiger's diet which together contributed 89.46% of its diet during 2005-06 (Fig. 5.29). Chital 39.8%) and sambar (21.9%) contributed major portion of tiger diet in 2005-06. Wild prey contributed 84.6% of tiger diet but livestock (both cow and buffalo) also contributed significant proportion (15.4%) in the tiger's diet in 2005-06.

Estimation of relative biomass contributed by different prey species to tiger diet during 2005-05 is provided in Table 5.6. In terms of frequency of occurrence, in scats, chital contributed around two times (39.8%) more than sambar (21.89%) but its biomass (25.67%) contribution was less than to biomass contributed by sambar (33.99%). The combined biomass contributed by chital, sambar, wild pig, nilgai and langur to the tiger diet was 72.3%. Domestic livestock contributed 25.4% to the tiger diet.

Prey Selectivity

Comparison of observed and expected frequency of occurrence of prey species, in tigers scats, indicated significant difference in utilization of prey species by tigers and rejected the hypothesis of non selective predation by tigers during 2005-06 (χ^2 = 396.2, d. f. = 12, P< 0.01). Comparison of observed and expected proportions of prey species (ungulates) in tigers scats based on their individuals density and group density in survey area indicated the selection of prey species by tigers and indicated preference or avoidance of prey species during 2005-06 . When individual density was used to calculate expected proportion of scats, sambar, wild pig and nilgai were found to be utilized more than their availability whereas chital, muntjac and langur were found to be used less than their availability (Fig. 5.30). But in case, when group density of prey species was used to calculate expected proportion of scats, chital, wild pig and nilgai were found to be utilized more than their availability and sambar and muntjac were found to be utilized less their availability whereas langur was found to be used in accordance to its availability in the study area (Fig. 5.30).

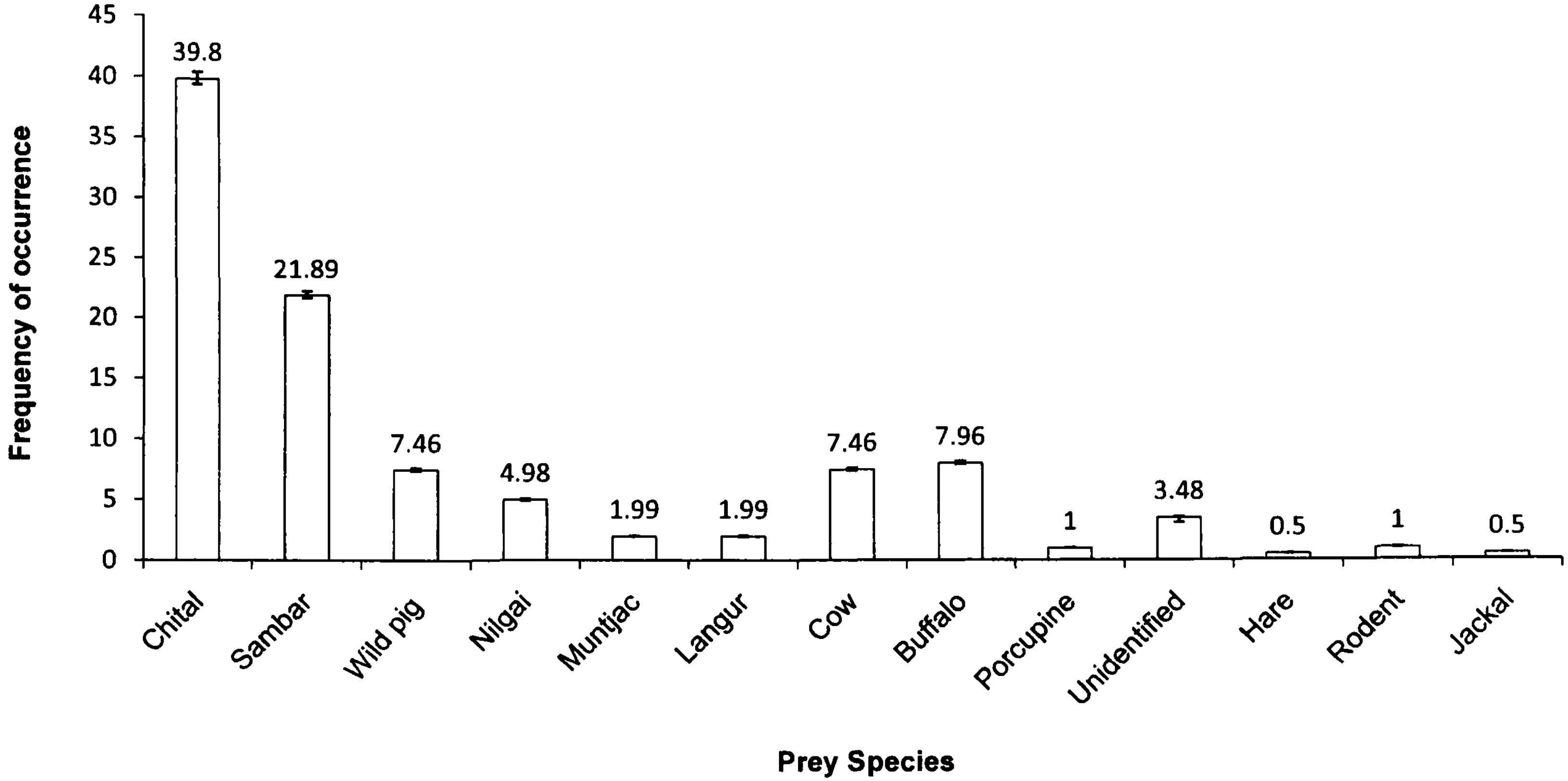


Figure 5.29: Food habits of the tiger in buffer zone of the Corbett Tiger Reserve (2005-06). Error bars show 95% bootstrap confidence interval (n=204).

Table 5.6: Composition of tiger scats (n=204), together with estimated relative biomass and number of prey consumed in the buffer zone of the Corbett Tiger Reserve

Prey Species	Weight of animal	% Relative estimated bulk	Collectable scat/kill	Biomass/ 100 scat (Kg)	% Biomass eaten	No. of individual eaten/100 scat	Ratio of number of individual eaten
Chital	55	39.80	14.08	155.42	25.67	2.83	1.00
Sambar	212	21.89	22.55	205.77	33.99	0.97	0.34
Wild pig	38	7.46	11.48	24.70	4.08	0.65	0.23
Nilgai	184	4.98	21.85	41.89	6.92	0.23	0.08
Muntjac	20	1.99	7.46	5.33	0.88	0.27	0.09
Langur	9	1.99	3.92	4.57	0.75	0.51	0.18
Cow	180	7.46	21.74	61.79	10.21	0.34	0.12
Buffalo	273	7.96	23.67	91.82	15.17	0.34	0.12
Porcupine	14	1.00	5.67	2.46	0.41	0.18	0.06
Unidentified	5	3.48	2.32	7.50	1.24	1.50	0.53
Hare	3	0.50	1.44	1.04	0.17	0.35	0.12
Rodent	0.113	1.00	0.06	1.97	0.33	17.47	6.18
Jackal	10	0.50	4.29	1.16	0.19	0.12	0.04

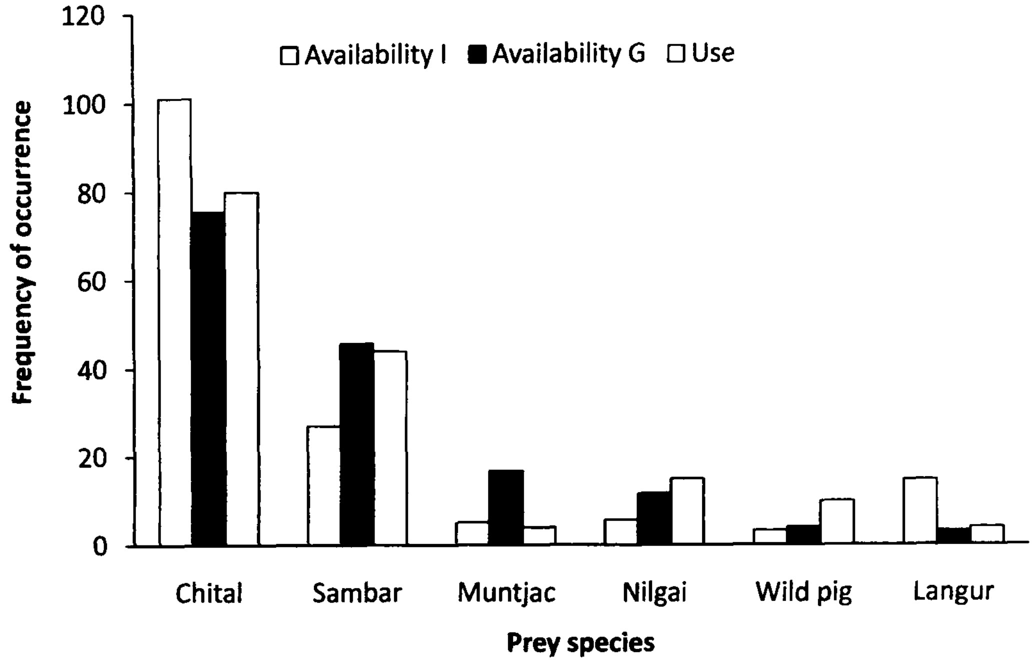


Figure 5.30: Comparison of observed and expected proportions of prey use in scats based on individual and group densities of prey species of tiger in the buffer zone of the Corbett Tiger Reserve. **Availability I, Availability G**, expected proportions of prey species in tiger scats calculated from density of individual and group of prey species respectively.

(D) Food habits of tiger (2006-07)

Out of 174 scats, 119 scats contained single prey species, 52 scats contained two prey species while only 3 scats contained three prey species (Fig. 5.31). The overall tiger diet diversity in 2006-07 was 2.132. A total of 12 prey species were recorded in the diet of tiger during 2006-07.

Percent occurrence of different prey species in tiger scats, in buffer zone of the Corbett Tiger Reserve, indicated that large prey species (chital, sambar, wild pig, nilgai, cow and buffalo) are principal prey and they together contributed 90.8% of its diet during 2006-07 (Fig. 5.32). Chital (36.78%) and sambar (25.86%) both were contributed major portion of tiger diet in

2006-07. Wild prey contributed 84.5% of tiger's diet but livestock (both cow and buffalo) also contributed significant proportion (15.5%) in the tiger's diet in 2006-07.

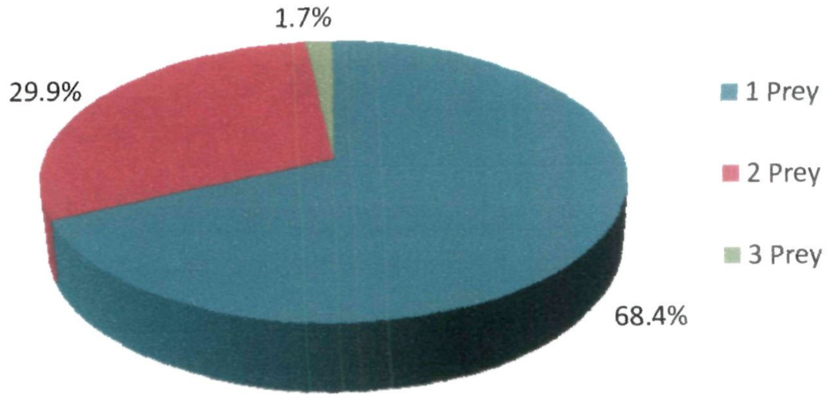


Figure 5.31: Proportion of scats in relation to number of prey detected in a single scat (2006-07)

Estimation of relative biomass contributed by different prey species to tiger diet is provided in Table 5.7. In terms of frequency of occurrence, in tiger's scats, chital (36.78%) contributed more than sambar (25.86%) but its biomass contribution was less than to biomass contributed by sambar. The combined biomass contributed by chital, sambar, wild pig, nilgai, muntjac and langur to the tiger diet was 75.8%. Domestic livestock contributed 22.26% to the tiger diet.

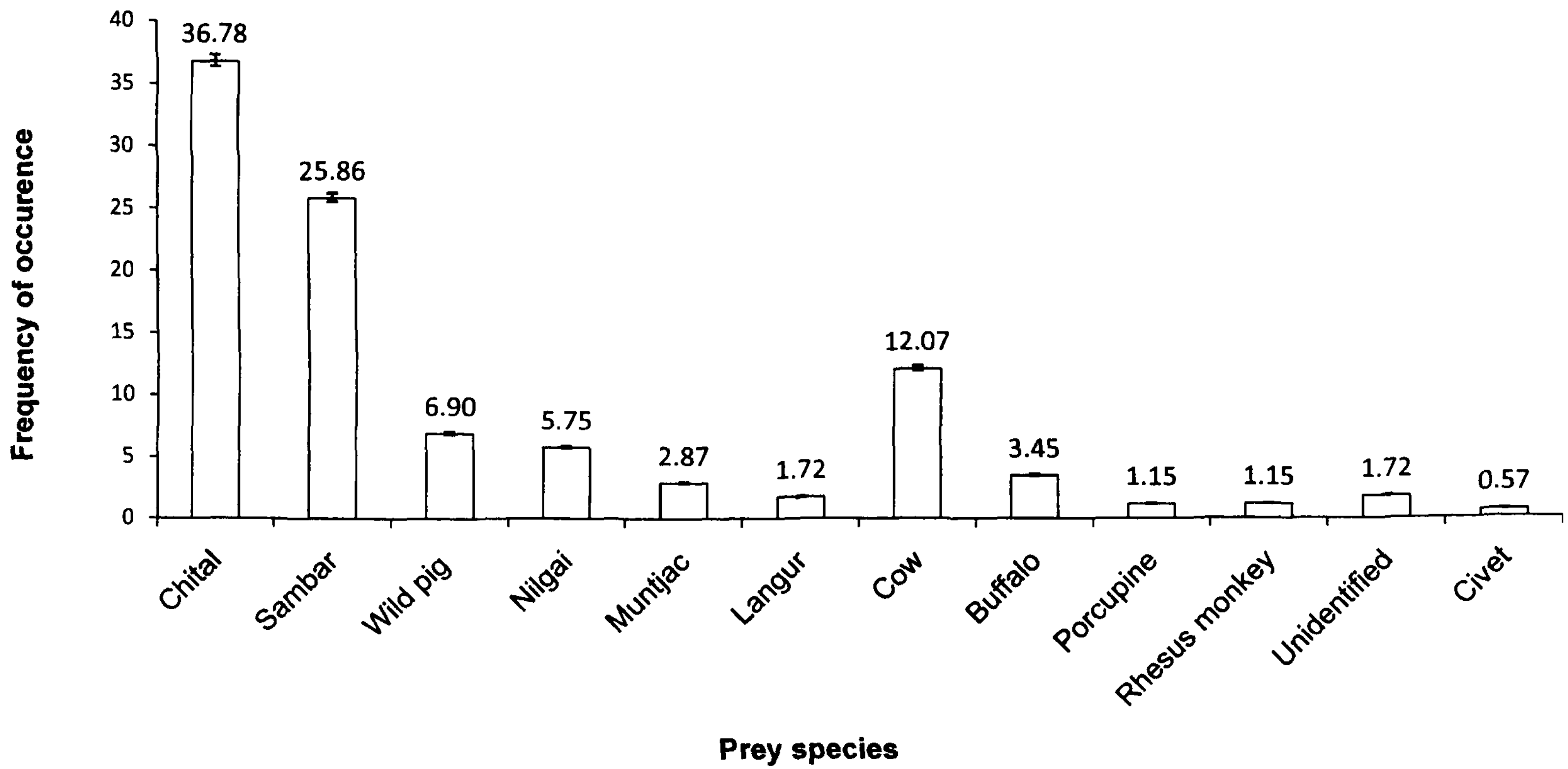


Figure 5.32: Food habits of the tiger in the buffer zone of the Corbett Tiger Reserve (2006-07). Error bars show 95% confidence interval (n=174)

Table 5.7: Composition of tiger scats (n=174), together with estimated relative biomass and number of prey consumed in the buffer zone of the Corbett Tiger Reserve (2006-07)

Prey Species	Weight of animal	% Relative estimated bulk	Collectable scat/kill	Biomass/ 100 scat (Kg)	% Biomass eaten	No. of individual eaten/100 scat	Ratio of number of individual eaten
Chital	55	36.78	14.08	143.63	23.18	2.61	1.00
Sambar	212	25.86	22.55	243.10	39.24	1.15	0.44
Wild pig	38	6.90	11.48	22.83	3.68	0.60	0.23
Nilgai	184	5.75	21.85	48.39	7.81	0.26	0.10
Muntjac	20	2.87	7.46	7.70	1.24	0.39	0.15
Langur	9	1.72	3.92	3.96	0.64	0.44	0.17
Cow	180	12.07	21.74	99.93	16.13	0.56	0.21
Buffalo	273	3.45	23.67	39.78	6.42	0.15	0.06
Porcupine	14	1.15	5.67	2.84	0.46	0.20	0.08
Rhesus monkey	4	1.15	1.89	2.44	0.39	0.61	0.23
Unidentified	5	1.72	2.32	3.72	0.60	0.74	0.28
Civet	3	0.57	1.44	1.20	0.19	0.40	0.15

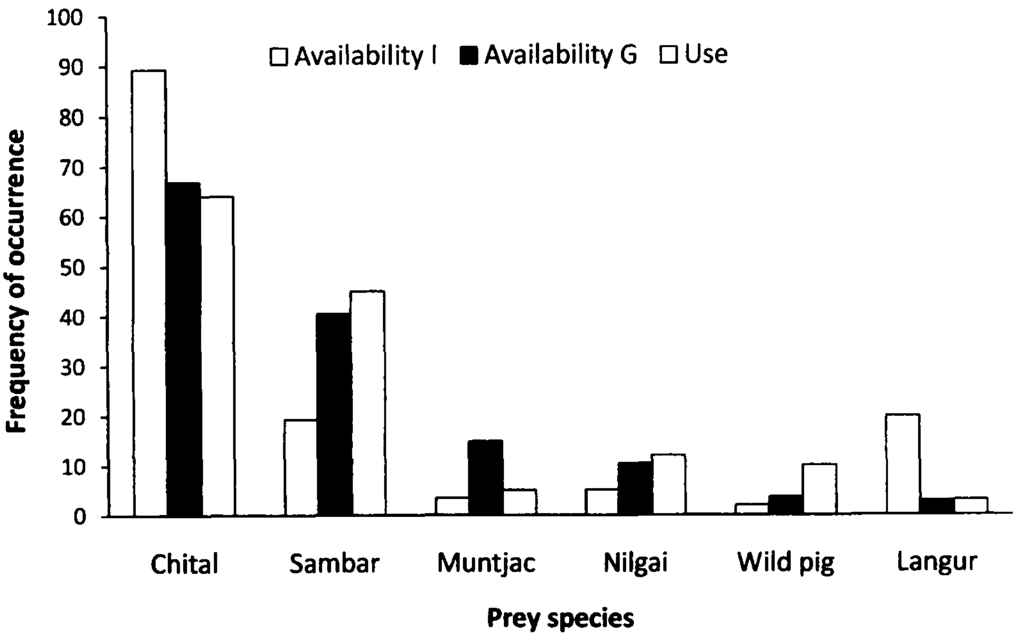


Figure 5.33: Comparison of observed and expected proportions of prey use in scats based on individual and group densities of prey species of tiger in the buffer zone of the Corbett Tiger Reserve. **Availability I, Availability G**, expected proportions of prey species in tiger scats calculated from density of individual and group of prey species respectively.

Prey Selectivity

Comparison of observed and expected frequency of occurrence of prey species in tiger scats indicated significant difference in utilization of prey species by tigers and rejected the hypothesis of non selective predation by tigers during 2006-07 (χ^2 = 301.57, d. f. = 11, P< 0.01). Comparison of observed and expected proportions of prey species (wild prey) in tigers scats based on their individuals density and group density in survey area indicated the selection of prey species by tigers during 2006-07. When individual density was used to calculate expected proportion of scats, sambar, muntjac, wild pig and nilgai were found to be utilized more than their availability whereas chital and langur were found to be utilized less than their availability (Fig. 5.33). But when group density was used to calculate expected proportion of scats, sambar, wild pig and nilgai were found to be utilized more than their availability whereas chital and muntjac were found to be utilized less than their availability and langur was found to be utilized in accordance to its availability in the study area (Fig. 5.33).

Year wise variation

Two way analysis of variance with years and prey species as main factor showed that there was no significance difference in occurrence of prey species in the diet of tiger (F= 0.01, df = 2,28, P= 0.99). However species were differently eaten during years (F= 27.35, df= 14, 28, P= 1.22E-12)

5.4 Conclusion & discussion

5.4.1 Monitoring of kills

Predominant use of neck bite (strangulation) for killing of prey by tiger recorded during the study support earlier observations on tigers (Schaller 1967, Sunquist 1981, Seidensticker & McDougal 1993, Karanth & Sunquist 2000). Use of unusual technique for killing of prey by sub-adult and cub might be due to lack of experience in killing of prey. Since study was conducted in the buffer zone, having high anthropogenic pressure of local people, therefore tigers hide the kills under the pressure of anthropogenic activities and to save it from other scavengers. To avoid the mixing of gut, tigers separate the gut portion.

Monitoring of kill indicated that tiger kills more females in comparison of males. Since kill monitoring is biased towards livestock and number of females was more in comparison of males in livestock holding by local people. Therefore, chance of encounter of females was more in comparison of males. Majority of kills were located in the mixed vegetation because mixed vegetation is more diverse in species diversity and used more by herbivores to graze. In addition mixed vegetation also preferred by local people to graze their livestock. Therefore, in mixed vegetation tigers had more chance of encounter of prey and they killed maximum number of prey in mixed vegetation. Moreover, mixed vegetation has sufficient cover, necessary to capture and to feed upon prey species.

Tigers mostly killed prey in low cover categories (0-20, 20-40 categories). Since visibility is significantly high in these areas and help tigers in handling big prey species. Therefore tiger mostly attacked big prey species in the open areas. Karanth and Sunquist (2000) reported that visibility was significantly higher in areas where tigers attacked gaur *(Bos gaurus)*. Majority of kills located close to the water (500 m to 1000m) and support the statement that both tigers and leopards attacked most of their prey either adjacent to or close to habitat features where they concentrate to feed or drink (Karanth & Sunquist 2000). To increase their chance of encounter with prey, tiger attaches with water body where prey species come frequently to drink water.

Maximum numbers of kills were found in plain topography. Plain areas were more utilized by local people for grazing their livestock. In addition to this, areas with plain topography is preferred by chital (Berwick 1974), principal prey species of tiger, therefore tigers also concentrate more in areas with plain topography and killed more prey species in the plain in comparison of other areas. In the buffer zone, tigers dragged the carcass of prey species to safer place to avoid disturbance from local people and other scavengers.

To maximize the energy gain from the preyed species, large carnivores prefer to kill large prey species but at the same time, they seem to take into consideration the ability to handle the prey species and risk factor as some large prey species counter attack the predator. Throughout the global range of tiger, large prey species contributes major proportion of the tiger's diet (Nowell & Jackson 1996, Karanth & Sunquist 1995). Findings of the present study suggest that tigers killed more large prey species in comparison to smaller prey species. Even in the same species tiger preferred to kill the adult animals in comparison of sub adult and calves and support the above statement.

Results (Fig. 5.3) showed that tigers killed more prey species during the monsoon because the rate of decomposition of carcass in monsoon increases and the tigers were not able to utilize the maximum portion of prey and this might have compelled them to kill another prey.

Tiger killed more animals in good and average health categories in buffer zone of the Corbett Tiger Reserve. Tiger killed more prey in good physical health as reported in several others studies (Schaller 1967, Karanth & Sunquist 1995). To maximize the benefit, tiger select the animal in good health and avoid the poor but selection also depends on the prey anti-predator behavior than on the prey species. In species that were more alert carnivores prefer the substandard individuals since individuals with good physique are difficult to capture (Temple 1987). Since our data was biased towards the livestock, which usually is not very alert, easy to capture, so tiger killed more individuals in good and average health in comparison to poor individuals.

Findings of the study suggest that determination of carnivore's diet from monitoring of kill data is biased towards large prey species because of human bias and thus underestimating the contribution of smaller animals (Karanth & Sunquist 1995).

5.4.2 Scat Analysis

Several investigators have been investigated feeding habits of carnivores (Johnsingh 1983, Norton et al. 1986, Palmer & Fairall 1989, Windberg & Mitchell 1990, Karanth & Sunquist 1995, Sankar & Johnsingh 2002, Biswas & Sankar 2002, Bagchi et al. 2003, Kumar et al. 2004, 2007, Habib 2007) through identifying prey species by hair characteristics from their remains in the scats. But only few recent studies on coyotes by Windberg and Mitchell

(1990), on leopard and Asiatic lion by Mukherjee et al. (1994 a, b), on tiger by Biswas and Sankar (2002) and Bagchi et al. (2003) and wolves by Jethva and Jhala (2003) and Habib (2007) have mentioned the minimum number of scats and hairs per scats that to be examined to determine the feeding habits of carnivore species. The present study, conducted in the buffer zone of Corbett Tiger Reserve, has also standardized the minimum number of hairs that needed to be scanned per scat in order to detect the presence of 95% and 100% of the prey species occurring in the diet of tigers. Our results indicated that for determining the 95% of the prey items, per scat 18-20 hairs need to be analyzed where as determining 100% of the food items 28-30 hairs per scat need to be scanned. Since 69 % of the scats contained a single prey item, so picking up and scanning 1 or 2 or 18 hairs from such scats, which contain single prey item will produce the same results. Addition of each new hair in 69% of the scats will not have any effect in determining the mammalian prey species found in the scats. Our results clearly explain this. The graph (Fig. 5.14) at hair number one has explained more than 69% accuracy in determining the mammalian prey specie. In the present study, the majority (69%) of the tiger scats contained only one prey species. Similar result reported from Rajaji National Park (Harihar et al. 2006) and Ranthambore National Park (Bagchi et al. 2004) where respectively 77.27% and 58% tiger's scat contained single prey species. Multiple prey items are uncommon in scats of large carnivores such as tiger (Biswas & Sankar 2002, Bagchi et al. 2003) and in Asiatic lion *Panthera leo* (Mukherjee et al. 1994a), whereas they are common in smaller carnivores like canids (Reynolds & Aebischer 1991).

Occurrence of single prey in majority of scats support the fact that tiger favor the large prey and after feeding on the large prey, there is no need to kill another prey individual thus reducing the chances of production of multiple prey scats.

Percent occurrence of each prey species in scats was used in increments of 10 scats. "Observation area curve" (Odum & Kuenzler 1965) method results indicated that, to determining feeding habits of tiger in the study area, 70 scats need to be analyzed. In difference to result of present study, Biswas and Sankar (2002), Bagchi et al. (2003) recorded that 50 scats need to be analyzed to determine feeding habits of tigers based on scats collected from Pench Tiger Reserve and Ranthambore National Park respectively. According to Khan (2004) 34 scats are sufficient to determine the feeding habits of tiger in Sundarban. The present study was conducted in the buffer zone of the CTR, where diversity in the tiger's diet is more in comparison of core areas therefore need more scats to be analyzed to determine the feeding habits.

Food habits of tiger

Large prey species (sambar, chital, wild pig, nilgai, cow and buffalo) were found to be favored by tigers in comparison of smaller prey species and this may be considered in the light of optimal foraging theory (Stephens & Krebs 1987), which states that predators may select prey species containing the most profitable prey as measured by the ratio of energy gain to searching and handling time (Mac Arthur & Pianka 1966, Scheel 1993, Karanth & Sunquist 1995). In accordance with several studies (McDougal 1977, Sunquist 1981, Johnsingh, 1983, Karanth & Sunquist 1995, Stoen & Wegge 1996, Biswas & Sankar 2002) cervids (chital and sambar and muntjac) contributed major portion (63.09%) of biomass consumed by tiger in the buffer zone of the Corbett Tiger Reserve.

Table 5.8 provides the comparison of frequency of occurrence of different prey species in tiger's diet in different areas. On comparison of contribution of chital and sambar with different areas, it was found that if the predation rate is high on the chital, then the contribution of sambar is relatively low and vice-versa. This clearly indicates that chital and sambar were the most important prey species of tiger all over its range

When compared to studies from other areas, the predation rate on livestock species (cow and buffalo) by tigers was found to be relatively high in study area in comparison of other areas. All the sites, where predation rate on livestock was low, either include core zone of protected areas or conducted in the core zone of protected area where entry of livestock is restricted by forest department whereas present study is exclusively conducted in buffer zone of the Corbett Tiger Reserve. Local people regularly graze livestock in buffer zone and high availability of livestock species in buffer zone gives rise to high rate of predation on livestock species by tiger in comparison of other areas.

Table 5.8: Frequency of occurrence of major prey species in tiger *Panthera tigris tigris* scats from different areas of the Indian subcontinent

Species	Corbett	Pench	Kanha	Bandipur	Nagarhole	Chitwan	Bardia
Chital	40	53.01	52.2	39	31.2	33.3	77.7
Sambar	23.2	13.78	10.4	30.5	24.9	29.3	-
Muntjac	1.9	5.34	-		6.1	4.1	-
Barasingha	N.P	N.P	8.6	N.P.	N.P.	N.P.	1.4
Hog deer	-	N.P	N.P	N.P.	N.P.	15.4	7.7
Wild pig	6.5	8.88	0.8[a]	5.5	9.4	10.6	8.8
Gaur	N.P	-	8.3	5.5	17.4	N.P.	N.P.
Nilgai	4.8	-	-	N.P.	N.P.	-	1.9
Chowsingha	N.P	2.67	-	-	-	N.P.	N.P.
Common Langur	1.9	3.65	6.2	-	3.9	5.7	2.3
Cow	9.2	4.34	5.9	5.5[b]	-	-	-
Buffalo	5.6	2	1.7	-	-	-	-
Others	6.9	6.33	6.1	14	7.1	1.6	5.2

[a] Both domestic and wild dog

[b] Domesticated livestock as a wholeCorbett, Present study; Pench, Biswas & Sankar (2002); Kanha, Schaller (1967); Bandipur, Johnsingh (1983); Nagarhole, Karanth & Sunquist (1995); Chitwan, McDougal (1977); Bardia, Stoen & Wegge (1996).

Results of reconstruction of diet suggest that corrections applied to frequencies of occurrence of prey types in scats (Flyod et al. 1978, Ackerman et al. 1984) were useful in overcoming biasness caused by difference in prey size and helpful in determining actual importance of prey species in the diet of carnivores.

Results from prey selectivity (Scat analysis) analysis indicated that selective predation by tigers was directed towards prey species with large body mass and large prey species contributed 89.3% of tiger's diet in buffer zone of Corbett Tiger Reserve. Karanth and Sunquist (1995) reported similar selective predation of tigers towards large bodied prey in Nagarhole National Park. Chital in terms of number of individuals eaten, contributed maximally to the diet of tiger in the study area and was under utilized by tiger in relation to its availability, only when individual density was used to calculate expected proportion of scats except during 2002-03. This could be because of low sample size of scat analyzed for this period. Only, 38 scats were analyzed for this period, which is not sufficient sample size to determine the dietary spectrum of tiger. Several other investigators reported similar under use of chital by tiger, when compared to its availability (Johnsingh 1983, Karanth & sunquist 1995, Stoen & Wegge 1996) whereas Biswas and Sankar (2002) reported its utilization in proportion to its availability. Chital forms large groups and this gregarious nature of chital is also supposed to be one of the factors that reduce the chances of tiger predation on chital (Karanth & Sunquist 1995). In terms of frequency of occurrence, sambar formed the second most important prey species for the tiger in the buffer zone of the Corbett Tigers Reserve and was consumed more than its availability when the selectivity was conducted using both density of individuals and groups. Similar pattern of overutilization of sambar by tiger was reported from Pench when individual densities were used to calculate availability of prey base (Biswas & Sankar 2002).

Wild pig in the study area was consumed more than its availability in the study area. Similar overutilization of wild pig by tiger has also been reported by Sankar and Biswas (2002) in Pench Tiger Reserve and indicated habitat overlap between tiger and wild pig. The overutilization of nilgai might be because of tiger's preference towards the larger prey species and both tiger and nilgai utilize more plain areas and might be this habitat overlap is one of the factors behind overutilization of nilgai by tiger. Selective predation on muntjac by tiger in the study area might be considered rare event since this species is too small to be profitable prey for tigers. It occurs in very low density and prefers hilly terrain and able to quickly disappear in the bushes. It is very difficult for tigers to prey on muntjac. Langur was under utilized by tigers because of its arboreal nature. Common langur spends most of their time on the tree so it is not possible for tigers to prey on them and hence they represent small portion of tiger's diet.

Comparison of results of kill monitoring and scat analysis suggests that proportion of young animals (Schaller 1967, Sunquist 1981, Johnsingh 1983, Karanth 1995), or of smaller species (Ruggiero 1991), in carnivore diets solely from kill data may be biased and underestimates. Through kill data, it was found that tiger favored livestock but through the scat analysis chital and sambar were found to be major prey species of tiger. This biasness towards the livestock was because of human bias and inability to find out the tiger's kills because of dense cover and secretive nature of tiger. Due to this, scat analysis was given preference over the kill monitoring in determination of carnivores diet.

3.1 Introduction

One of the most important objectives in the management strategy of wildlife protected areas is the successful conservation of wild ungulate communities as they form part of a larger prey-predator system and therefore, often the survival of many endangered carnivore species- tiger, lion and leopard depend upon their prey population (Khan 1993).

Several recent studies (Karanth & Sunquist 1995, Miquelle et al. 1996, Karanth & Nichols 1998) have found that abundance of predators, like the tiger, is influenced by the distribution and abundance of its prey species. Distribution and abundance of potential prey species has profound influence on the quality of a predator's habitat and the health of predator populations and this information about prey species is vital to understand ecology of concerned predator species. Prey selection and food habits of predators are governed by absolute abundance and relative abundance of principal prey species (Estabrook & Dunham 1976) and these factors interrelated with each other. Optimal foraging theory predicts that higher abundance of potential prey species results in greater specialization by increased selection for the most profitable prey species (Pyke et al. 1977).

Monitoring of wild prey base is imperative for developing management strategies for tiger conservation. Firstly, carnivores are very much dependent on the wild animals on which they prey therefore their sound management requires estimates of wild prey species. Secondly, herbivore populations are good indicators of overall changes in the quality of various habitat types because wild herbivore populations are directly affected by the overall changes in the structure and composition of various habitat types. So it is desirable to monitor the status and distribution of wild prey species in the tiger range areas.

Depletion of tiger natural prey base by habitat destruction, poaching and by competition from domestic cattle for land is rapidly becoming the most serious threat to the tiger survival over its whole range (Karanth & Stith 1999) and responsible for the past decline of tiger over its entire range. Abundance of prey species is most important factor in the ecology of carnivores and able to shape the distribution and abundance of predators. So the estimation of abundance of prey species is most crucial for tailoring the management strategies for the tiger. So a sound understanding of the population structure and the abundance of wild ungulates, which plays significant role in shaping of the tiger distribution, is crucial for long-term survival of tiger.

3.2 Methodology

Both direct (Distance sampling) and indirect (Pellet count) techniques were used to estimate abundance of major tiger prey species in the study area. In addition to this, forest department census data was also used to calculate block-wise density and biomass of ungulate prey species of tiger.

Distance sampling (Buckland et al. 1993, 2001, 2004) technique accounts for decreasing detectability of animals with increasing distance from the observer and estimate density while allowing some animals to go undetected (Buckland et al. 2004). Four major assumptions of distance sampling are: 1) objects are randomly distributed, 2) objects on the line are always detected, 3) objects are detected at their initial location before any movement in response to the observer, and 4) distances are measured accurately (Buckland et al. 2004). But distribution of prey species is determined by the availability of resources and they congregate in open areas having grass and water. Therefore to meet the first assumption, sampling linesshould be placed randomly.

Line transect methodology (Buckland et al. 1993, 2001, 2004, Karanth et al. 2002) was used to estimate density of different prey species. To avoid any bias, during the first phase of study 21 permanent transects were randomly laid and marked across different forest blocks in the buffer zone of the CTR (Map 14). The transect length varied between 1.6 km to 3.5 km, depending upon the terrain in which they were located. During the second phase of the study, only 8 transects were monitored and transect length varied from 2-3 km. Two to three observers walked each transect in morning and evening hours. For each sighting of prey species on transect, the data were collected on 1) species sighted, 2) number of individuals in-group, 3) age and sex of species, 4) perpendicular distance using a range finder.

The data were collected during morning and afternoon hours. Sampling was started 30 minutes after the sunrise in the morning and during afternoon hours in such a manner that the transect monitoring was finished about 30 minutes before the sunset. Transects were walked in the opposite directions for any two consecutive days to minimize any bias of not using the area by the animals due to observer's presence and due to the differential use of habitats by them. The animals on either side of the transect line were counted and grouped into different age and sex classes. Laser range finder (Bushnell Yardage Pro 1000®, Bushnell Corp., Overland Park, Kans.) was used to measure distance. For a group of animals and large herds distance up to the centre of the herd was measured.

Apart from line transects, which covered only 11 blocks of buffer zone, indirect method of pellet group count was also used for relative abundance estimation of different prey species in different forest blocks of buffer zone. Pellet groups of different prey species were identified and recorded in 10 m radius circular random plots established in each block (Appendix IV). The pellet groups of different species were identified on the basis of differences in size, shape and colour of pellets. The forest department conducts regular block-wise census of all ungulates.

Census data of prey species were also collected for year 2003 from the forest department for comparison with direct sighting data. To know the population structure of prey species, in addition to the data collected during transect monitoring, data on age and sex of prey species was also collected randomly. Age and sex of individuals was recorded whenever a group of prey species encountered in the study area. Individuals of group of prey species were classified into the adult male (AM), yearling male (YM), adult female (AF), yearling female (YF) and fawn (F). The unclassified individuals of a group were categorized as unidentified (UNI)

3.3 Analysis

The analysis was carried out separately for major prey species of tiger. An overall, annual variations in density, cluster size, effective strip width and encounter rate were estimated using DISTANCE 5.0 Release Beta 5 (Thomas et al. 2005). The AIC (Akaike's Information Criteria) values generated by DISTANCE for various models in analysis offer a compromise between the quality of the fit and increased number of model parameters and are important in selecting a particular model, goodness-of-fit tests generated by the program DISTANCE, and also by visually judging the fit of the proposed model to the observed distance data. The best possible model was selected based on the above considerations. The model (key function, with the appropriate adjustment term where necessary) best describing the detection process was selected on the basis of minimum or lowest AIC value among different models, which is computed as:

$$\mathbf{AIC = -2 \log e (£) + 2}\boldsymbol{k}$$

Where log e (£) is the log likelihood function evaluated at the maximum likelihood estimates of the model parameters, and k is the number of parameters in the model (Buckland et al. 1993, 2001, 2004, Burnham et al. 1980, Burnham & Anderson 1998, 2002). Because AIC cannot be used to choose a specific model among different models that have different truncation distances. Model selection was carried out only after the truncation distance and distance intervals were selected (Buckland et al. 1993, 2001, 2004). Variance of the mean density was estimated as composite variance of group size, encounter rate and the effective strip width (ESW). Animal densities were computed by multiplying the estimated cluster densities by the cluster size. Expected cluster size was estimated based on the regression of:

log(s (i)) on g(x (i))
x (i) - Distance to i-th observation
s (i) - Cluster size of i-th observation

The parameters such as encounter rate (n/L), density of animals (D), density of clusters (DS), effective strip width (ESW), expected cluster size (ES) and mean cluster size (MS) were estimated. These variables are estimated by the program DISTANCE based on variation in Uniform, Half Normal and Hazard Rate detectability models (Buckland et al. 2004). The equations for different detectability models used are:

Uniform key, k(y) = 1/W
Half-normal key, k(y) = Exp (-y2/ (2*A (1) **2))**
Hazard Rate key, k(y) = 1 – Exp (-(y/A (1)) **-A (2))
W - Width of line transect or radius of point transect
A (I) - i-th parameter in the estimated probability density function (pdf)

To determine the prey biomass available for the tiger in the study area, density of prey species was multiplied by the average weight of prey species. Average weight of prey animals were taken from Karanth and Sunquist (1995) and Biswas and Sankar (2002)

The pellet group data collected by random sampling in forest blocks were used to calculate pellet group densities. The mean pellet group score (pellet groups/point) of a species for a particular block was calculated by dividing the total number of pellet groups sampled at all points in a block by the total number of points sampled in that particular block. The mean pellet group scores were converted into pellet group densities (number of pellet groups/ha). The mean pellet group scores were also used to categorize different forest blocks in terms of having low, medium and high abundance of wild prey (Table 6.1).

Table 6.1: Scores assigned for prey abundance assessment (random pellet group sampling in forest blocks) in the buffer zone of the Corbett Tiger Reserve

Category	Chital	Sambar	Muntjac	Nilgai	Wild pig
Prey abundance:					
(Mean pellet group/plot)					
Low	0-1.6	0-1.3	0-0.29	0.01-0.38	0-0.17
Medium	>1.6-3.2	>1.3-2.6	>0.29-0.58	>0.38-0.75	>0.17-.34
High	>3.2-4.8	>2.6-3.9	>0.58-0.87	>0.75-1.01	>0.34-0.51

The data collected from forest department were used to calculate block-wise densities of different prey species by dividing number of individuals of a species by the area of the forest block. The densities were then used to calculate block-wise biomass of different species. On the basis of density and biomass values of prey species, blocks were ranked as low, medium and high in terms of abundance of wild prey (Table 6.2).

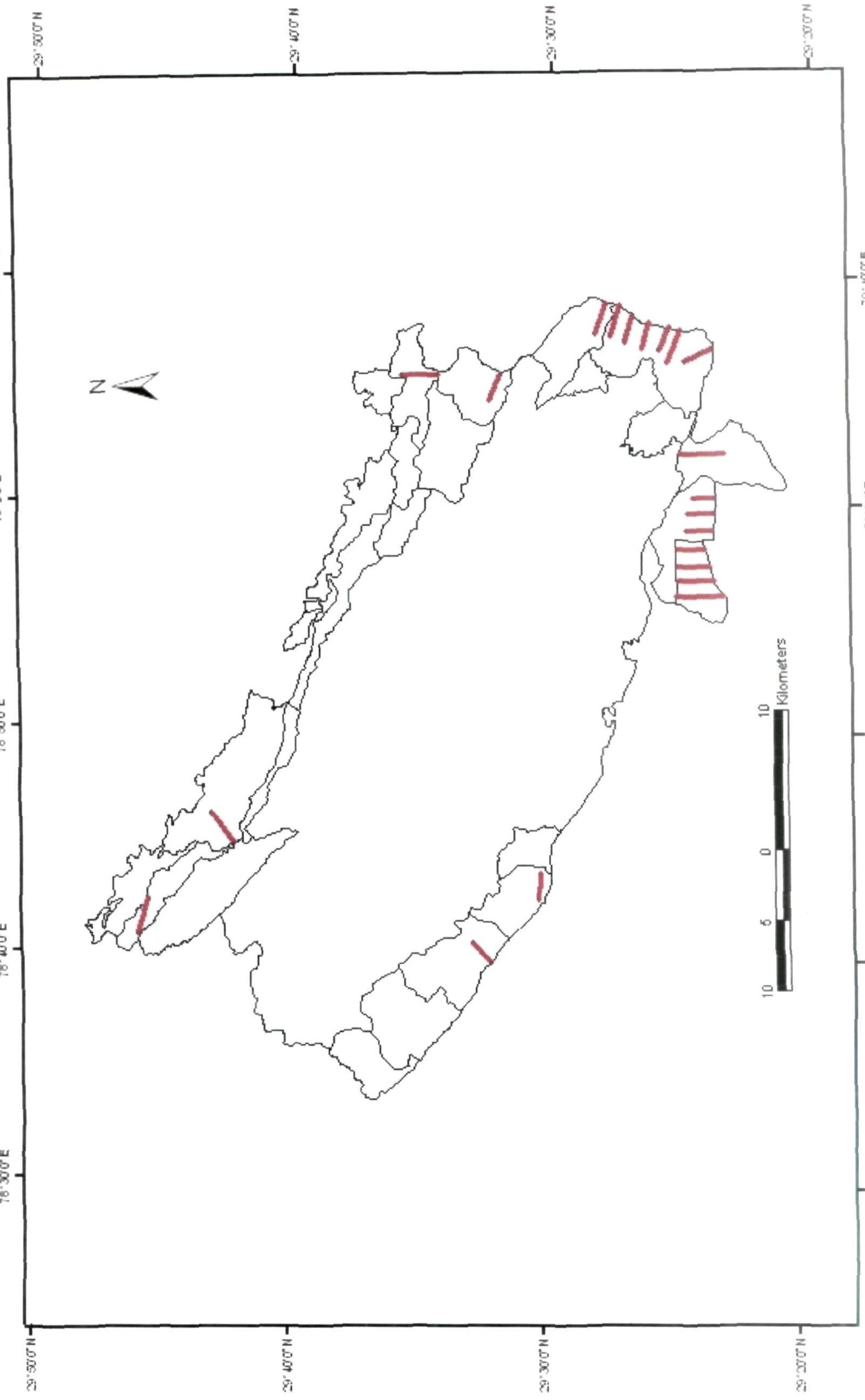
To determine the group composition and population structure of prey species, all the data was segregated into different age and sex categories. From this information, sex ratio and proportion of different age classes for different prey species were calculated. Average group size with standard error was calculated to know the group characteristic of the tiger prey species. Groups were further categorized into small, medium and large on the basis of number of individuals. For chital, groups having 1-5 individuals were considered as a small group; 6-10 individuals as a medium and groups having >10 individuals were considered as a large groups while in case of sambar, nilgai and wild pig groups having 1-2 individuals were considered as a small; 3-4 as a medium and >4 individuals as a large group. But for the muntjac, I categorized them as solitary and pair.

Table 6.2: Scores assigned for density and prey biomass assessment (forest census data) in the buffer zone of the Corbett Tiger Reserve

Category	Chital	Sambar	Muntjac	Wild pig	All prey species
Density (animals/ km^2):					
Low	1-20	1-2	0.1-0.5	1-3	-
Medium	>20-40	>2-4	>0.5-1	>3-6	-
High	>40	>4	>1	>6	-
Biomass (Kg/km^2):					
Low	1-1200	1-500	1-15	1-100	1-1500
Medium	>1200-2400	>500-1000	>15-30	>100-200	>1500-3000
High	>2400	>1000	>30	>200	>3000

3.4 Results

To estimate the density of major tiger prey species, 21 transects in different blocks and habitat types were walked (Table 6.3). A total of 567 km of distance was covered during the study period. The results of the study are applicable only to the buffer zone of the Corbett Tiger Reserve, and cannot be extrapolated for the entire Corbett Tiger Reserve.



Map 14: Location map of line transects in buffer zone of the CTR

Table 6.3: Details of transects in buffer zone of the Corbett Tiger Reserve

Transect number and bearing	Habitat type	Forest block	Transect length (km)
1- Bajari road to ahead of Sikarikuan	Sal, Mixed	North Jashpur	2.3
2- Dhela to Patrani road	Mixed, Plantations	Dhela	2.2
3- Sanwalde to Hathidangar	Sal, Mixed, Plantations	Sanwalde Bhavar	3.0
4- Chorpani to Aamdanda Ka nala	Sal, Mixed	Phooltal	2.9
5- Dhikuli to Teenpani	Mixed	Dhulwa east	2.0
6- Bhootgadi to Sultan	Mixed, Sal Mixed	Dumunda east	2.0
7- Chimtakhal to Durgadevi	Mixed, Sal, Riverine	Jamariya	2.0
8- Vatanvasa to Baherbadi	Sal, Mixed	Haldgaddi	2.0
9- Kugadda to Gunetha	Sal, Mixed	Kugadda	2.0
10- Kalushahid tiraha to Kalushahid	Mixed, Riverine	Kalushahid	2.0
11- Nalkatta to Hatiyasot	Mixed, Plantations	Nalkatta	2.0
12- Phanto to Phikka nadi	Mixed, Plantations	North Jashpur	3.5

Transect number and bearing	Habitat type	Forest block	Transect length (km)
13- Before Phanto to Bajari road	Sal, Mixed	North Jashpur	2.6
14- Sikarikuan to Bajari road	Sal, Mixed	North Jashpur	2.0
15- Before Sikarikuan to Bajari road	Sal, Mixed, Khair-Sisso	Dhela	1.6
16- Dhela to Patrani	Mixed, Plantations	Dhela	1.75
17- Aamdanda to Bijrani road	Mixed, Plantations	Phooltal	2.0
18. Ahead of Ringora to Phooltal	Mixed, Plantations	Phooltal	2.0
19- Mazar to Phooltal Chaur	Mixed, Plantations	Phooltal	2.0
20- Ladua to Phooltal Chaur	Mixed, Plantations	Phooltal	2.0
21- Garjia to Bazar ka Chaur	Mixed, Plantations	Dhulwa east	2.0

3.4.1 Detection Function, Models and Estimation of Individual Density, Group Density, Effective Strip Width, Cluster Size and Encounter Rate

All Prey: Based on comparison of AIC values, the half normal key function with four cosine adjustments (cosine 2, 3, 4, 5) fitted the data of all prey for the years 2002-03 and half normal key function with one cosine adjustment (cosine 2) fitted the data for 2005-06 where as half normal key function with three cosine adjustments (cosine 2, 3, 4) fitted the overall data combined for the period 2002-03 and 2005-06. Goodness-of-fit tests indicated a good fit of the data to a distance model for each year: overall (13 χ = 94.3, P = 0.00000), year 2002-03 (15 χ = 257.4, P = 0.00000), year 2005-06(27 χ = 99.91, P= 0.00000). Density of individuals (Table 6.4) varied from 64.27 ± 8.1 individuals/km^2 for 2002-03, 58.29± 5.51 individuals/km^2 for 2005-06 and 58.38 ± 4.11 individuals/ km^2 for combined data (pooled data).

Density of groups (Table 6.4) was found to be 12.71 ± 1.15 groups/km^2 during 2002-03, 15.52 ± 1.11 groups/km^2 in 2005-06 and 13.93 ±.76 groups/km^2 for combined data for both period (pooled data).

Effective strip width (Table 6.4) was highest (42.25 m) during the 2002-03 and lowest (34.7 m) during 2005-06. The expected cluster size for the best-selected model on the basis of minimum AIC value was minimum (3.75 ± 0.19) in the year 2002-03 and maximum (5.05 ± 0.44) in 2005-06 (Table 6.5). Mean cluster size for all the model keys namely uniform, half normal and hazard rate remained same between the competing models. It was highest (5.21 ±0.41) during the year 2002-03 and lowest (3.98 ± 0.22) during the year 2005-05. The 95% confidence limits overlapped in all the categories (Fig. 6.2).

Encounter rate was highest during the year 2005-06 (1.31 animal groups/km) where as it was lowest during the year 2002-03 (0.88 animal groups/km) (Table 6.5).

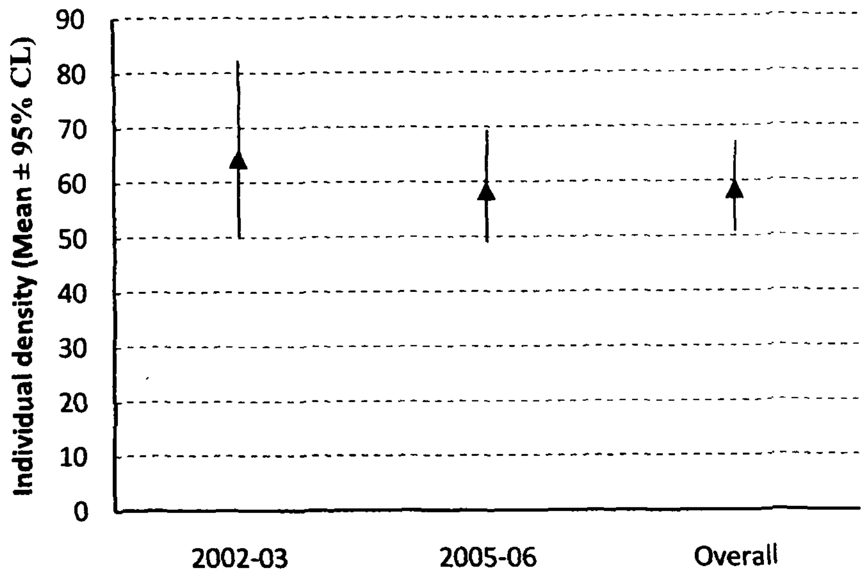


Figure 6.1: Variation of mean density of all animals with 95% confidence intervals

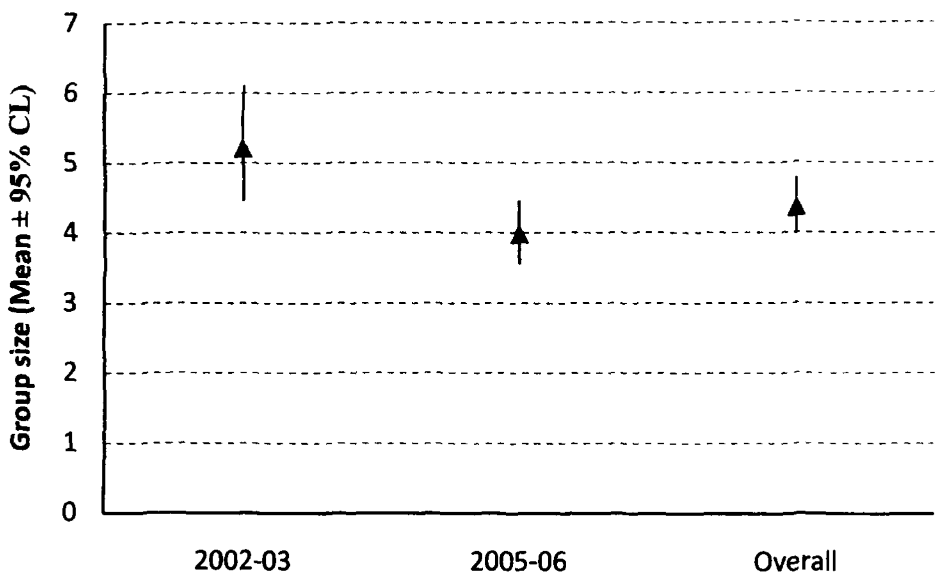


Figure 6.2: Variation of mean cluster size of all animals with 95% confidence intervals

Table 6.4: Competing models and associated number of model parameters (k), Akaike's Information Criteria (AIC) values, goodness-of-fit (GOF) *P*-values and density estimates (D = density of individuals, DS = density of clusters of all prey/km^2) and effective strip width (ESW) for distance data of **all prey species** in the buffer zone of the Corbett Tiger Reserve

Year/ Model Key	Adjustment	K	AIC	GOF	Individual density D	SE	95%CL	Group density DS	SE	95%CL	Effective strip width EWS	SE	95%CL	X^2	DF
2002-2003															
Half-normal	cosine 2, 3, 4, 5	5	1691.42	0.41	64.27	8.1	50.2-82.27	12.7	1.15	10.63-15.21	34.7	1.6	31.68-38.02	257.36	15
Uniform	cosine 1, 2, 3	3	1769.92	0.41	34.79	4.37	27.2-44.5	6.71	0.6	5.612-8.02	65.72	2.96	60.12-71.84	153.91	17
Hazard-rate	cosine 2	3	1565.64	0.41	260.3	41.6	190.5-355.7	51.8	6.94	39.86-67.37	8.51	0.92	6.88-10.54	41.89	17
2005-2006															
Half-normal	cosine 2	2	3864.37	0.17	58.29	5.51	49.02-69.32	15.5	1.11	13.49-17.87	42.25	1.87	38.71-46.1	99.91	27
Uniform	cosine 1, 2, 3, 4	4	3864.49	0.17	57.69	5.23	48.3-68.92	15.4	1.14	13.28-17.79	42.67	2.09	38.75-46.983	79.5	25
Hazard-rate	cosine 2	3	3864.47	0.17	56.57	4.63	48.17-66.43	15.1	0.95	13.31-17.09	43.49	1.29	41.03-46.1	87.53	26
Overall															
Half-normal	cosine 2, 3, 4	4	5566.04	0.25	58.39	4.14	50.81-67.09	13.9	0.76	12.51-15.52	40.95	1.16	38.72-43.31	94.3	13
Uniform	cosine 1, 2, 3	3	5743.88	0.25	40.04	2.91	34.71-46.18	9.65	0.55	8.82-10.8	59.14	1.94	55.43-63.09	500232	26
Hazard-rate	None	2	5583.14	0.25	51.37	3.74	44.52-59.26	12.3	0.7	10.99-13.77	46.39	1.54•	43.46-49.51	121.64	27

Table 6.5: Estimation of Expected Cluster Size (ES), Mean Cluster Size (MS) and Encounter Rate (ER/km) of different tiger prey species in the buffer zone of the Corbett Tiger Reserve. Parameter estimates and associated measures of variance were based on the model with least Akaike's Information Criteria (AIC) value

Species/ Year	Model key	Adjustment	K	AIC	GOF	Expected Cluster size			Mean Group size			Encounter rate				
						ES	SE	95%CL	MS	SE	95%CL	ER	SE	95%CL	X^2	DF
All prey																
2002-03	Half-normal	cosine 2,3,4,5	5	1691.4	0.41	5.05	0.44	4.25-5.99	5.21	0.41	4.45-6.1	0.88	0.06	0.75-1.03	257.4	15
2005-06	Half-normal	cosine 2	2	3864.4	0.17	3.75	0.19	3.39-4.15	3.98	0.22	3.55-4.45	1.31	0.07	1.17-1.46	99.91	27
Overall	Half-normal	cosine 2,3,4	4	5566	0.25	4.18	0.18	3.38-4.57	4.36	0.2	3.97-4.78	1.14	0.05	1.04-1.25	94.3	13
Chital																
2002-03	Half-normal	Cosine 2, 3, 4	4	939.79	0.36	5.16	0.51	4.24-26.28	5.21	0.47	4.35-6.23	0.47	0.05	.38-.59	30.58	10
2005-06	Uniform	Cosine 1,2	2	1776.7	0.16	4.62	0.3	4.05-5.25	4.82	0.29	4.27-5.44	0.6	0.04	0.51-0.7	41.44	18
Overall	Half-normal	cosine 1, 2,3,	4	2721.1	0.23	4.77	0.26	4.29-5.31	4.95	0.25	4.48-5.48	0.55	0.03	.48-.63	54.22	21
Sambar																
2002-03	Half-normal	Cosine 2	2	250.15	0.43	1.71	0.18	1.37-2.12	1.7	0.23	1.28-2.24	0.13	0.02	0.09-0.19	10.19	5
2005-06	Uniform	cosine 1	1	809.14	0.18	2.04	0.12	1.8-2.31	1.93	0.13	1.68-2.21	0.27	0.03	0.21-0.33	20.4	12
Overall	Uniform	cosine 1,2,3	3	1073.9	0.24	1.92	0.1	1.73-2.14	1.87	0.11	1.66-2.12	0.21	0.02	.17-.26	16.3	12
Muntjac																
2002-03	Half-normal	Cosine2	2	154.54	0.55	1	0	0	1	0	0	0.08	0.02	0.05-0.13	3.27	3
2005-06	Uniform	Cosine 1,2	2	573.78	0.17	1.05	0.02	1-1.11	1.08	0.06	1-1.21	0.2	0.02	0.15-0.26	18.15	9
Overall	Uniform	cosine 1,2	2	732.24	0.25	1.04	0.02	1-1.08	1.06	0.46	1-1.16	0.15	0.01	.12-.2	11.57	11
Nilgai																
2002-03	Uniform	None	0	26.58	0.33	0.01	0.01	0.004-0.03	1	0	0	1	0	0	0.33	1
2005-06	Uniform	cosine 1	1	135.29	0.22	2.78	0.72	1.59-4.87	4.07	0.88	2.55-6.48	0.04	0.01	0.02-0.07	4.83	3
Overall	Uniform	Cosine 1	1	163.84	0.18	2.58	0.65	1.51 -4.41	3.52	0.78	2.21-5.61	0.02	0.01	.012 -.05	5.21	4
Wild pig																
2002-03	Half-normal	Cosine 2	2	87.13	0.6	4.31	1.26	2.22-8.36	3.8	0.67	2.54-5.67	0.04	0.01	0.02-0.0.7		
2005-06	Half-normal	None	1	343.48	0.17	1.7	0.16	1.39-2.07	1.8	0.2	1.42-2.26	0.11	0.01	0.08-0.16	7.81	7
Overall	Uniform	cosine 1, 2	2	430.41	0.26	2.2	0.22	1.78 - 2.71	2.2	0.23	1.76-2.73	0.08	0.01	.06-.11	10.69	7
Langur																
2002-03	Half-normal	Cosine 2	2	224.35	0.42	13.6	2.09	9.91-18.61	13	1.5	10.22-16.43	0.12	0.02	0.08-0.17	4.3	4
2005-06	Uniform	Cosine 1	1	197.48	0.4	16.8	2.12	12.92-21.76	16.2	1.59	13.19-19.79	0.07	0.01	0.05-0.1	8.46	5
Overall	Half-normal	cosine 2	2	421.14	0.41	14.3	1.42	11.76 -17.48	14.5	1.1	12.41-16.86	0.09	0.01	.07 - 2.12	14.28	7

Chital: Based on comparison of AIC values, the half normal key function with three cosine adjustments (cosine 2, 3, 4) fitted the data of chital for the years 2002-03 and uniform key function with two cosine adjustments (cosine 1, 2) fitted the data for 2005-06 whereas half normal key function with three cosine adjustments (cosine 1, 2, 3) fitted the overall data combined for the period 2002-03 and 2005-06. Goodness-of-fit tests indicated a good fit of the data to a distance model for each year: overall (21 χ = 54.22, P = 0.00009), year 2002-03 (10 χ = 30.58, P = 0.00069), year 2005-06(18 χ = 41.44, P= 0.00132). Competing models showed good-fit values of P from 0.00000 to 0.00132. Density of individuals (Table 6.6) varied from 30.78 ± 5.15 individuals/km^2 for 2002-03, 31.95± 3.68 individuals/km^2 for 2005-06 and 32.55 ± 3.22 individuals/km^2 for combined data (pooled data).

Density of groups (Table 6.6) was found to be 5.95 ± 0.8 groups/km^2 during 2002-03, 6.91 ±0.65 groups/km^2 in 2005-06 and 6.8 ±.56 groups/km^2 for combined data for both period (pooled data).

Effective strip width (Table 6.6) was highest (43.75 m) during the 2005-06 and lowest (40.2 m) during 2002-03. The expected cluster size for the best-selected model on the basis of minimum AIC value was minimum (4.62 ± 0.3) in the year 2005-06 and maximum (5.16 ± 0.51) in 2002-03 (Table 6.5). Mean cluster size for all the model keys namely uniform, half normal and hazard rate remained same between the competing models. It was highest (5.21 ±0.47) during the year 2002-03 and lowest (4.82 ± 0.29) during the year 2005-05. The 95% confidence limits overlapped in all the categories (Figure 6.4).

Encounter rate was highest during the year 2005-06 (0.6 animal groups/km) where as it was lowest during the year 2002-03 (0.47 animal groups/km) (Table 6.5).

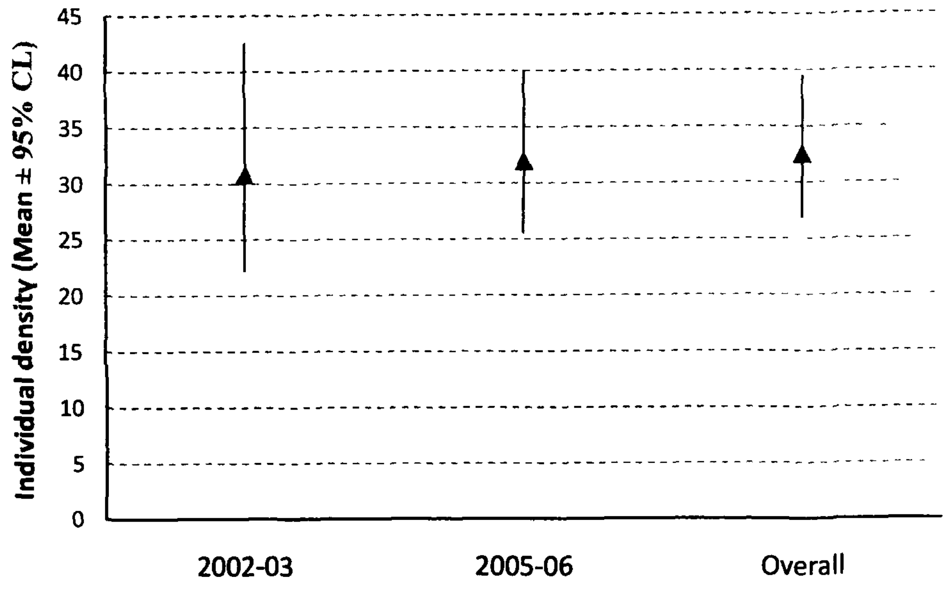


Figure 6.3: Variation of mean density of chital with 95% confidence intervals.

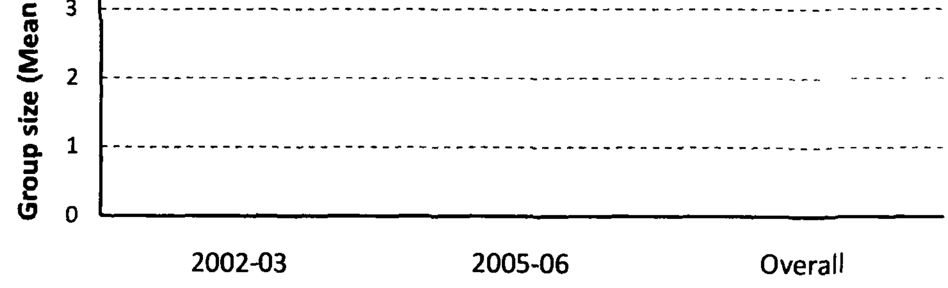


Figure 6.4: Variation of mean cluster size of chital with 95% confidence intervals

Table 6.6: Competing models and associated number of model parameters (k), Akaike's Information Criteria (AIC) values, goodness-of-fit (GOF) *P*-values and density estimates (D = density of individuals, DS = density of clusters of chital/km^2) and effective strip width (ESW) for distance data of **chital** in the buffer zone of the Corbett Tiger Reserve

Year/ Model Key	Adjustment	K	AIC	GOF	Individual density			Group density			Effective strip width				
					D	SE	95%CL	DS	SE	95%CL	EWS	SE	95%CL	X^2	DF
2002-03															
Half-normal	Cosine 2, 3, 4	4	939.79	0.361	30.78	5.15	22.19-42.6	5.95	0.8	4.57-7.76	40.2	3.17	34.38-47	30.58	10
Uniform	Cosine 1, 2, 3	3	969.67	0.361	19.69	3.24	14.26-27.18	3.74	0.49	2.89-4.85	63.96	4.7	55.29-73.99	59.96	11
Hazard-rate	Cosine 2	3	887.36	0.361	139.7	30.1	91.78-212.57	25.7	4.92	17.69-37.37	9.31	1.46	6.83-12.69	23.4	11
2005-06															
Half-normal	Cosine 1, 2	3	1779.97	0.16	31.23	4.44	23.65-41.24	6.69	0.84	5.23-8.57	45.17	4.36	37.33-54.61	44.32	17
Uniform	Cosine 1, 2	2	1776.7	0.16	31.95	3.68	25.48-40.05	6.91	0.65	5.73-8.33	43.73	2.15	39.68-48.2	41.44	18
Hazard-rate	None	2	1778.59	0.16	30.1	3.7	23.66-38.3	6.39	0.66	5.21-7.84	47.3	3.08	41.9-53.78	47.35	18
Overall															
Half-normal	cosine 1, 2, 3,	4	2721.13	0.23	32.55	3.22	26.81-39.53	6.8	0.56	5.79-8.01	40.72	2.07	36.83-45.01	54.22	21
Uniform	cosine 2, 3, 5	3	2798.15	0.24	20.6	1.94	17.12-21.78	4.22	0.32	3.62-4.91	65.58	2.68	60.6-71.18	101.09	22
Hazard-rate	None	2	2727.67	0.23	29.43	2.89	24.21-35.68	6.06	0.49	5.16-7.11	45.78	2.26	41.53-50.46	31.99	23

Sambar: Based on comparison of AIC values, the half normal key function with one cosine adjustment (cosine 2) fitted the data of sambar for the years 2002-03 and uniform key function with one cosine adjustment (cosine 1) fitted the data for 2005-06 where as uniform key function with three cosine adjustments (cosine 1, 2, 3) fitted the overall data combined for the period 2002-03 and 2005-06. Goodness-of-fit tests indicated a good fit of the data to a distance model for each year: overall (12 χ= 16.3, P = 0.17747), year 2002-03 (5 χ = 10.19, P = 0.06996), year 2005-06 (12 χ = 20.4, P= 0.05983). Competing models showed good-fit values of P from 0.00000 to 0.17747. Density of individuals (Table 6.7) varied from 3.24 ± 0.75 individuals/km^2 for 2002-03; 5.34 ± 0.79 individuals/ km^2 for 2005-06 and 4.4 ± 0.57 individuals/km^2 for combined data (pooled data).

Density of groups (Table 6.7) was found to be 1.9± 0.39 groups/km^2 during 2002-03, 2.61 ± 0.35 groups/km^2 in 2005-06 and 2.32 ±0.32 groups/km^2 for combined data for both period (pooled data).

Figure 6.5: Variation of mean density of sambar with 95% confidence intervals

Table 6.7: Competing models and associated number of model parameters (k), Akaike's Information Criteria (AIC) values, goodness-of-fit (GOF) *P*-values and density estimates (D = density of individuals, DS = density of clusters of sambar/km^2) and effective strip width (ESW) for distance data of **sambar** in the buffer zone of the Corbett Tiger Reserve

					Individual density			Group density			Effective strip width				
Year/ Model Key	**Adjustment**	**K**	**AIC**	**GOF**	**D**	**SE**	**95%CL**	**DS**	**SE**	**95%CL**	**EWS**	**SE**	**95%CL**	χ^2	**DF**
2002-03															
Half-normal	cosine 2	2	250.15	0.433	3.24	0.75	2.06-5.1	1.9	0.39	1.26-2.84	35.02	3.11	29.2-42	10.19	5
Uniform	cosine 1	1	272.05	0.45	1.51	0.32	.99-2.3	0.87	0.16	0.6-1.27	75.75	2.81	70.22-81.72	28.84	6
Hazard-rate	None	2	221.55	0.433	18.99	6.59	9.69-37.23	11.6	3.81	6.08-22.03	5.74	1.56	3.32-9.94	9.3	5
2005-06															
Half-normal	None	1	809.51	0.18	5.15	0.8	3.79-7	2.53	0.36	1.91-3.36	53.54	4.8	44.82-63.97	20.73	12
Uniform	cosine 1	1	809.14	0.18	5.34	0.79	3.99-7.14	2.61	0.35	2-3.4	52	3.93	44.76-60.41	20.4	12
Hazard-rate	cosine 1	1	809.14	0.18	5.34	0.79	3.99-7.14	2.61	0.35	2-3.4	52	0.39	44.76-60.41	20.4	12
Overall															
Half-normal	None	1	1074.9	0.24	4.39	0.53	3.45-5.58	2.27	0.25	1.83-2.83	47.57	2.52	42.82-52.85	52.72	14
Uniform	cosine 1, 2, 3	3	1073.94	0.24	4.4	0.57	3.48-5.76	2.32	0.27	1.85-2.92	46.58	3.01	40.98-52.94	16.3	12
Hazard-rate	cosine 2	3	1076.52	0.24	4.44	0.59	3.42-5.76	2.3	0.28	1.81-2.92	47.08	3.47	40.69-54.48	25.48	12

Effective strip width (Table 6.5) was highest (52 m) during the 2005-06 and lowest (35.02 m) during 2002-03. The expected cluster size for the best-selected model on the basis of minimum AIC value was minimum (1.71 ± 0.18) in the year 2002-03 and maximum (2.04 ± 0.12) in 2005-06 (Table 6.5).

Mean cluster size for all the model keys namely uniform, half normal and hazard rate remained same between the competing models. It was highest (1.93 ±0.13) during the year 2005-06 and lowest (1.7 ± 0.23) during the year 2002-03. The 95% confidence limits overlapped in all the categories (Figure 6.6).

Encounter rate was highest during the year 2005-06 (0.27 animal groups/km) where as it was lowest during the year 2002-03 (0.13 animal groups/km) (Table 6.5).

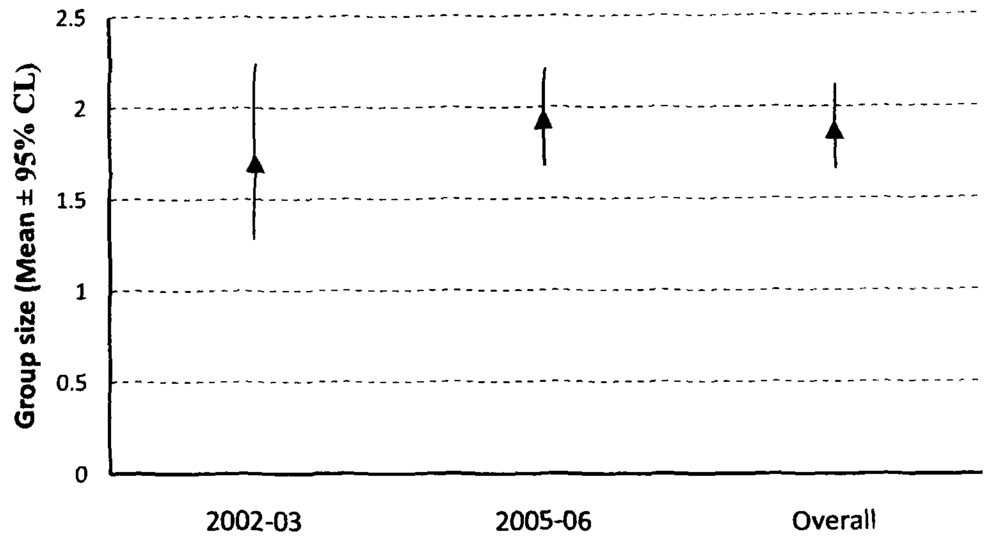


Figure 6.6: Variation of mean cluster size of sambar with 95% confidence intervals

Muntjac: Based on comparison of AIC values, the half normal key function with one cosine adjustment (cosine 2) fitted the data of muntjac for the years 2002-03 and uniform key function with two cosine adjustments (cosine 1, 2) fitted the data for 2005-06 and overall data combined for the period 2002-03 and 2005-06. Goodness-of-fit tests indicated a good fit of the data to a distance model for each year: overall (11 χ = 11.57, P = 0.39635), year 2002-03 (3 χ = 3.27, P = 0.35051), year 2005-06 (9 χ = 18.15, P= 0.03337). Competing models showed good-fit values of P from 0.00000 to 0.39635. Density of individuals (Table 6.8) varied from 2.02 ± 0.59 individuals/km^2 for 2002-03, 3.07± 0.51 individuals/km^2 for 2005-06 and 2.35 ± 0.33 individuals/km^2 for combined data (pooled data).

Density of groups (Table 6.8) was found to be 2.02 ± 0.59 groups/km^2 during 2002-03, 2.9 ± 0.47 groups/km^2 in 2005-6 and 2.26 ±0.31 groups/km^2 for combined data for both period (pooled data).

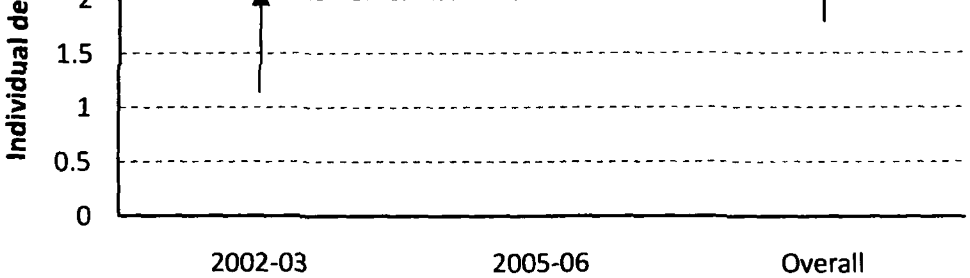


Figure 6.7: Variation of mean density of muntjac with 95% confidence intervals

Table 6.8: Competing models and associated number of model parameters (k), Akaike's Information Criteria (AIC) values, goodness-of-fit (GOF) *P*-values and density estimates (D = density of individuals, DS = density of clusters of muntjac/km^2) and effective strip width (ESW) for distance data of **muntjac** in buffer zone of the Corbett Tiger Reserve

Year					Individual density			Group density			Effective strip width				
Model Key	**Adjustment**	**K**	**AIC**	**GOF**	**D**	**SE**	**95%CL**	**DS**	**SE**	**95%CL**	**EWS**	**SE**	**95%CL**	**X^2**	**DF**
2002-03															
Half-normal	cosine 2	2	154.54	0.55	2.02	0.59	1.13-3.60	2.02	0.59	1.13-3.06	21.9	4	14.96-30.04	3.27	3
Uniform	cosine 1 ,2, 3	3	156.18	0.55	1.93	0.57	1.08-3.46	1.93	0.57	1.08-3.46	22.89	4.26	15.5-33.8	3.63	2
Hazard-rate	None	2	118.82	0.55	16.36	6.22	7.79-34.32	16.4	6.22	7.79-34.32	2.71	0.81	1.46-5.03	3.59	3
2005-06															
Half-normal	None	1	574.61	0.17	2.95	0.47	2.15-4.05	2.79	0.44	2.04-3.18	36.63	2.8	31.45-42.67	22.09	10
Uniform	cosine 1, 2	2	573.78	0.17	3.07	0.51	2.21-4.26	2.9	0.47	2.1-4.01	35.21	3.09	29.55-41.95	18.15	9
Hazard-rate	None	2	576.3	0.17	2.65	0.46	1.89-3.72	2.46	0.42	1.76-3.45	41.46	4.14	33.97-50.6	18.96	9
Overall															
Half-normal	None	1	732.7	0.25	2.33	0.32	1.77-3.06	2.23	0.3	1.7-2.92	35.42	2.31	31.12-40.33	16.36	12
Uniform	cosine 1, 2	2	732.24	0.25	2.35	0.33	1.79-3.1	2.26	0.31	1.72-2.96	35.08	2.39	30.63-40.17	11.57	11
Hazard-rate	Ran with errors														

Effective strip width (Table 6.8) was highest (35.21 m) during the 2005-06 and lowest (21.9 m) during 2002-03. The expected cluster size for the best-selected model on the basis of minimum AIC value was minimum (1 ± 0) in the year 2002-03 and maximum (1.05 ± 0.02) in 2005-06 (Table 6.5). Mean cluster size for all the model keys namely uniform, half normal and hazard rate remained same between the competing models. It was highest (1.08 ±0.06) during the year 2005-06 and lowest (1 ± 0) during the year 2002-03. The 95% confidence limits overlapped in all the categories (Figure 6.8).

Encounter rate was highest during the year 2005-06 (0.2 animal groups/km) whereas it was lowest during the year 2002-03 (0.08 animal groups/km) (Table 6.5).

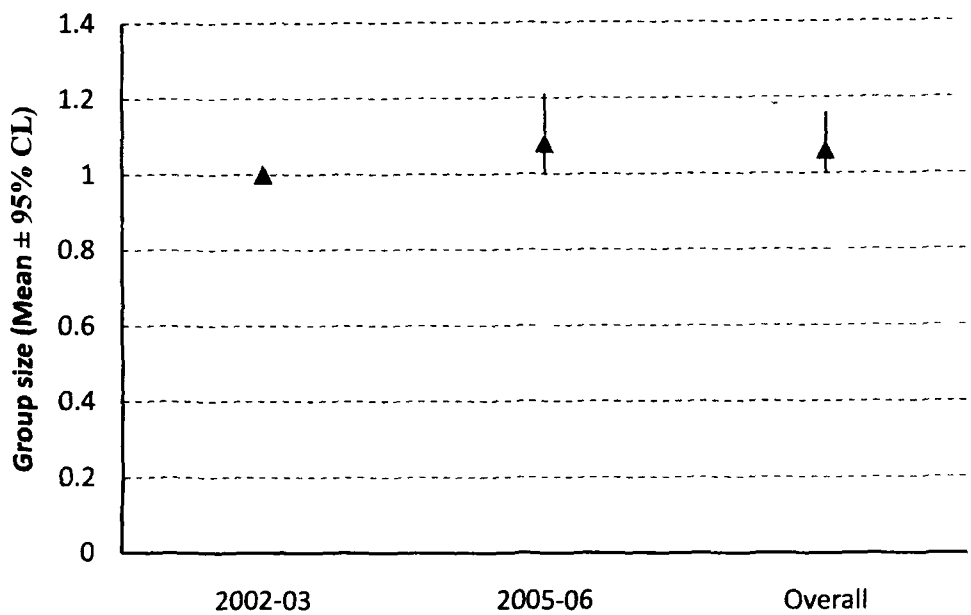


Figure 6.8: Variation of mean cluster size of muntjac with 95% confidence intervals

Nilgai: Based on comparison of AIC values, the uniform key function with none adjustment fitted the data of nilgai for the years 2002-03 and uniform key function with one cosine adjustment (cosine 1) fitted the data for 2005-06 and overall data combined for the period 2002-03 and 2005-06. Goodness-of-fit tests indicated a good fit of the data to a distance model for each year: overall (4χ = 5.21, P = 0.26602), year 2002-03 ($1\ \chi$ = 0.33, P = 0.5637), year 2005-06 ($3\ \chi$ = 4.83, P= 0.18414). Competing models showed good-fit values of P from 0.00000 to 0.5637. Density of individuals (Table 6.9) varied from 0.079 ± 0.04 individuals/km^2 for 2002-03, 0.73 ± 0.32 individuals/km^2 for 2005-06 and 0.47 ± 0.18 individuals/km^2 for combined data (pooled data).

Density of groups (Table 6.9) was found to be 0.07 ± 0.05 groups/km^2 during 2002-03, 0.26 ± 0.09 groups/km^2 in 2005-6 and 0.18 ± 0.52 groups/km^2 for combined data for both period (pooled data).

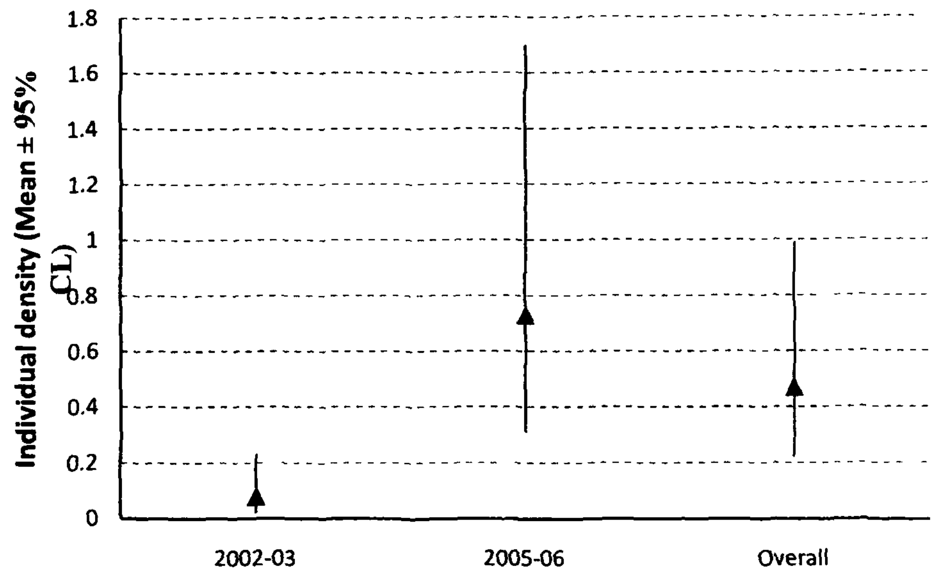


Figure 6.9: Variation of mean density of nilgai with 95% confidence intervals.

Effective strip width (Table 6.9) was highest (84 m) during the 2002-03 and lowest (81.94 m) for combined data. The expected cluster size for the best-selected model on the basis of minimum AIC value was minimum (0.01 ± 0.007) in the year 2002-03 and maximum (2.78 ± 0.72) in 2005-06 (Table 6.5).

Mean cluster size for all the model keys namely uniform, half normal and hazard rate remained same between the competing models. It was highest (4.07 ±0.88) during the year 2005-06 and lowest (1 ± 0) during the year 2002-03. The 95% confidence limits overlapped in all the categories (Figure 6.10).

Encounter rate was highest during the year 2002-03 (1 animal groups/km) where as it was lowest during the year 2005-06 (0.02 animal groups/km) (Table 6.5).

Figure 6.10: Variation of mean cluster size of nilgai with 95% confidence intervals

Table 6.9: Competing models and associated number of model parameters (k), Akaike's Information Criteria (AIC) values, goodness-of-fit (GOF) *P*-values and density estimates (D = density of individuals, DS = density of clusters of nilgai/km^2) and effective strip width (ESW) for distance data of **nilgai** in the buffer zone of the Corbett Tiger Reserve

Year/ Model Key	Adjustment	K	AIC	GOF	Individual density			Group density			Effective strip width			X^2	DF
					D	SE	95%CL	DS	SE	95%CL	EWS	SE	95%CL		
2002-02															
Half-normal	None	1	28.58	0.33	0.079	0.05	.01-.31	0.08	0.05	.01-.31	83.99	36.3	14.16-498.05		
Uniform	None	0	26.58	0.33	0.079	0.04	.02-2.23	0.08	0.05	.01-.31	84	0	84-84	0.33	1
Hazard-rate	None	2	30.58	0.33	0.079	0.04	.02-2.23	0.08	0.04	.02-2.23	84	0	83.97-84.02		
2005-05															
Half-normal	None	1	135.79	0.24	0.73	0.32	.31-1.7	0.26	0.09	.13-.53	75.82	12.6	53.13-108.18	4.64	3
Uniform	cosine 1	1	135.29	0.22	0.68	0.28	.3-1.5	0.24	0.08	.13-2.46	83.06	8.57	66.5-103.75	4.83	3
Hazard-rate	None	2	135.41	0.26	0.85	0.4	.34-2.11	0.27	0.11	.12-.59	74.78	19.2	43.09-129.79	3.43	2
Overall															
Half-normal	None	1	163.87	0.21	0.51	0.2	0.23-1.12	0.2	0.06	0.11-0.37	74.03	11.4	53.52-102.4	5.08	4
Uniform	cosine 1	1	163.84	0.18	0.47	0.18	0.22-0.99	0.18	0.52	0.1-0.31	81.94	7.3	67.86-98.94	5.21	4
Hazard-rate	None	2	163.85	0.21	0.59	0.25	0.25-1.36	0.19	0.07	0.1-0.39	75.38	17	46.9-121.15	3.59	3

***Wild pig*:** Based on comparison of AIC values, the half normal key function with one cosine adjustment (cosine 2) fitted the data of wild pig for the years 2002-03 and half normal key function with none adjustment fitted the data for 2005-06 where as uniform key function with two cosine adjustments (cosine 1, 2) fitted the overall data combined for the period 2002-03 and 2005-06. Goodness-of-fit tests indicated a good fit of the data to a distance model for each year: overall (7χ = 10.69, P = 0.15231), year 2005-06 (7χ = 7.81, P= 0.34896) while no test possible for year 2002-03. Competing models showed good-fit values of P from 0.00000 to 0.34896. Density of individuals (Table 6.10) varied from 2.88 ± 1.64 individuals/km^2 for 2002-03, 2.24 ± 0.49 individuals/ km^2 for 2005-06 and 2.3 ± 0.49 individuals/ km^2 for combined data (pooled data).

Figure 6.11: Variation of mean density of wild pig with 95% confidence intervals

Table 6.10: Competing models and associated number of model parameters (k), Akaike's Information Criteria (AIC) values, goodness-of-fit (GOF) *P*-values and density estimates (D = density of individuals, DS = density of clusters of wild pig /km^2) and effective strip width (ESW) for distance data of **wild pig** in buffer zone of Corbett Tiger Reserve

Year/ Model Key	Adjustment	K	AIC	GOF	Individual density			Group density			Effective strip width			X^2	DF
					D	SE	95%CL	DS	SE	95%CL	EWS	SE	95%CL		
2002-03															
Half-normal	cosine 2	2	87.13	0.6	2.88	1.64	.972-8.57	0.66	0.32	.25-1.76	33.19	13.1	13.84-79.58		
Uniform	Cosinec1, 2, 3	3	87.93	0.6	2.87	1.65	.95-8.68	0.66	0.33	.24-1.8	33.24	13.4	13.32-82.95		
Hazard-rate	None	2	66.52	0.6	25.54	14.8	8.42-77.33	6.05	3.03	2.24-16.35	3.66	1.69	1.48-9.03		
2005-06															
Half-normal	None	1	343.48	0.17	2.24	0.49	1.46-3.44	1.32	0.25	.89-1.93	44.24	4.67	35.74-54.75	7.81	7
Uniform	cosine 1, 2	2	343.83	0.17	2.44	0.55	1.56-3.8	1.42	0.29	.95-2.13	40.99	4.99	32.06-52.42	6.61	6
Hazard-rate	None	2	343.87	0.17	2.07	0.49	1.3-3.3	1.21	0.26	.79-1.86	48.14	6.88	36.09-64.2	5.8	6
Overall															
Half-normal	cosine 2	2	432.46	0.26	2.6	0.6	1.65-4.1	1.16	0.24	.77-1.74	37.93	5.68	28.11-51.18	11.95	7
Uniform	cosine 1, 2	2	430.41	0.26	2.3	0.49	1.51-3.5	1.04	0.19	.74-1.51	42.09	5.02	33.15-53.46	10.69	7
Hazard-rate	None	2	432.17	0.26	2.04	0.48	1.29-3.23	0.95	0.2	.63-1.44	46.05	7.01	33.96-62.45	11.99	7

Density of groups (Table 6.10) was found to be 0.66 ± 0.32 groups/km^2 during 2002-03, 1.32 ± 0.25 groups/km^2 in 2005-06 and 1.04 ±0.19 groups/km^2 for combined data for both period (pooled data).

Effective strip width (Table 6.5) was highest (44.24 m) during the 2005-06 and lowest (33.19 m) during 2002-03. The expected cluster size for the best-selected model on the basis of minimum AIC value was minimum (1.7±0.16) in the year 2005-06 and maximum (4.31 ± 1.26) in 2002-03 (Table 6.5).

Mean cluster size for all the model keys namely uniform, half normal and hazard rate remained same between the competing models. It was highest (3.8 ±0.67) during the year 2002-03 and lowest (1.8 ± 0.2) during the year 2005-05. The 95% confidence limits overlapped in all the categories (Figure 6.12).

Encounter rate was highest during the year 2005-06 (0.11 animal groups/km^2) where as it was lowest during the year 2002-03 (0.04 animal groups/km^2) (Table 6.5).

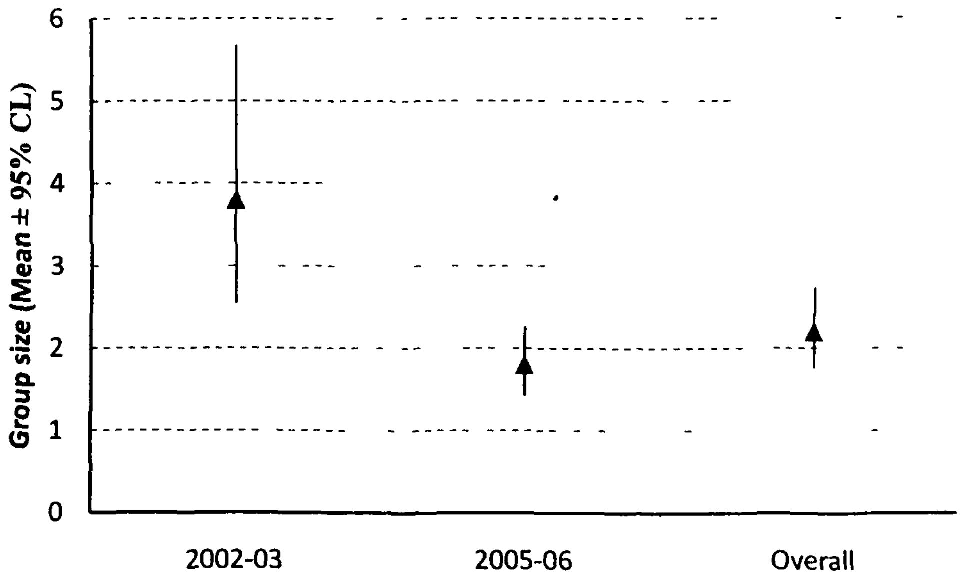


Figure 6.12: Variation of mean cluster size of wild pig with 95% confidence intervals

Langur: Based on comparison of AIC values, the half normal key function with one cosine adjustment (cosine 2) fitted the data of langur for the years 2002-03 and uniform key function with one cosine adjustment (cosine 1) fitted the data for 2005-06 where as half normal key function with one cosine adjustment (cosine 2) fitted the overall data combined for the period 2002-03 and 2005-06. Goodness-of-fit tests indicated a good fit of the data to a distance model for each year: overall (7 χ = 14.28, P = 0.04633), year 2002-03 (4χ = 4.3, P = 0.36631), year 2005-06 (5 χ = 8.46, P= 0.13236). Competing models showed good-fit values of P from 0.00000 to 0.36631. Density of individuals (Table 6.11) varied from 32.67 ± 9.28 individuals/km^2 for 2002-03, 16.69± 4.14 individuals/ km^2 for 2005-06 and 26.03 ± 5.25 individuals/ km^2 for combined data (pooled data).

Density of groups (Table 6.11) was found to be 2.4 ± 0.57 groups/km^2 during 2002-03, 1.05 ± 0.22 groups/km^2 in 2005-06 and 1.81 ±0.31 groups/km^2 for combined data for both period (pooled data).

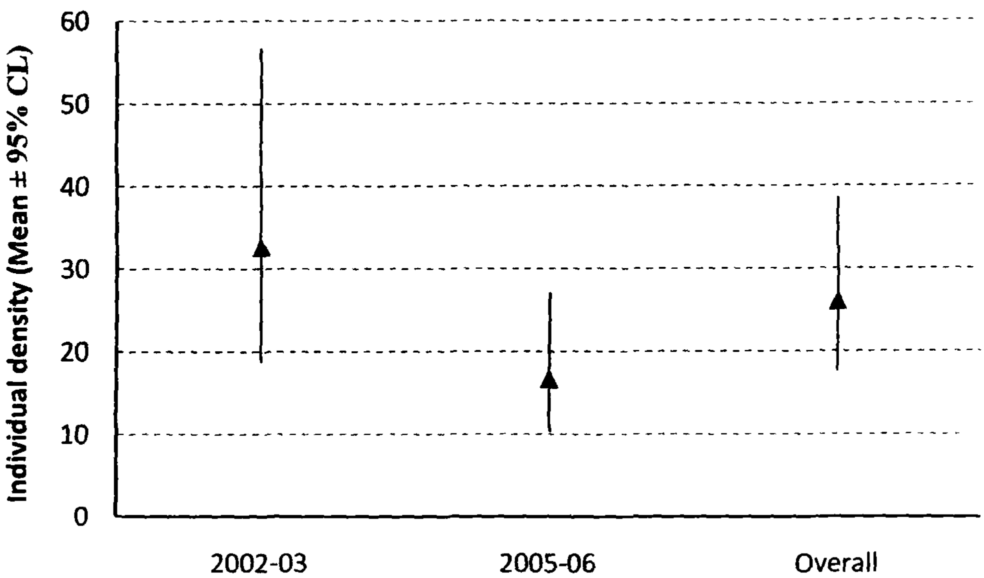


Figure 6.13: Variation of mean density of langur with 95% confidence intervals

Table 6.11: Competing models and associated number of model parameters (k), Akaike's Information Criteria (AIC) values, goodness-of-fit (GOF) *P*-values and density estimates (D = density of individuals, DS = density of clusters of langur/km^2) and effective strip width (ESW) for distance data of **langur** in the buffer zone of the Corbett Tiger Reserve

Year/ Model Key	Adjustment	K	AIC	GOF	Individual density			Group density			Effective strip width				
					D	SE	95%CL	DS	SE	95%CL	EWS	SE	95%CL	X^2	DF
2002-03															
Half-normal	Cosine 2	2	224.35	0.42	32.67	9.28	18.82-56.73	2.4	0.57	1.5-2.83	25.82	4	18.81-35.44	4.3	4
Uniform	cosine 1,2,3	3	224.82	0.42	32.54	9.07	18.92-55.95	2.38	0.55	1.5-3.75	26.09	3.79	19.37-35.14	3.78	3
Hazard-rate	None	2	190.9	0.42	232.4	86	112.92-478.11	16.5	5.58	8.47-31.97	3.77	1.08	2.11-6.72	6.75	4
2005-06															
Half-normal	None	1	198.09	0.4	17.39	4.56	10.43-28.97	1.1	0.25	0.7-1.73	33.15	4.43	25.17-43.64	8.95	5
Uniform	Cosine 1	1	197.48	0.4	16.69	4.14	10.29-27.07	1.05	0.22	0.69-1.6	34.59	3.57	27.96-42.78	8.46	5
Hazard-rate	Cosine 2	3	169.66	0.4	174.5	67.9	82.01-371.1	10.4	3.82	5.06-21.38	3.51	1.1	1.85-6.65	13.6	3
Overall															
Half-normal	cosine 2	2	421.14	0.41	26.03	5.25	17.55-38.6	1.81	0.31	1.28-2.56	25.72	2.97	20.4-32.42	14.28	7
Uniform	cosine 1,2,3	3	421.99	0.41	25.25	5.09	17.04-37.42	1.74	0.3	1.23-2.46	26.72	3.07	21.22-33.64	14.98	6
Hazard-rate	cosine 2,3,4	5	356.43	0.41	214.4	57.8	126.86-362.41	14.1	3.52	8.62-22.94	3.32	0.7	2.17-5.07	18.05	4

Effective strip width (Table 6.11) was highest (34.59 m) during the 2005-06 and lowest (25.72 m) for combined data. The expected cluster size for the best-selected model on the basis of minimum AIC value was minimum (13.58 ± 2.09) in the year 2002-03 and maximum (16.76 ± 2.12) in 2005-06 (Table 6.5).

Mean cluster size for all the model keys namely uniform, half normal and hazard rate remained same between the competing models. It was highest (16.2 ±1.59) during the year 2005-06 and lowest (13 ± 1.5) during the year 2002-03. The 95% confidence limits overlapped in all the categories (Figure 6.14).

Encounter rate was highest during the year 2002-03 (0.12 animal groups/km) where as it was lowest during the year 2005-06 (0.07 animal groups/km) (Table 6.5).

Figure 6.14: Variation of mean cluster size of langur with 95% confidence intervals

3.4.2 Biomass

Prey biomass contributed by all the prey species in the study area was 3137 kg/km^2 (Table 6.12). Figure 6.15 showed the biomass contributed by different prey species in the available prey biomass for the tiger in the study area. Chital and sambar together contributed over 88% of the available prey biomass in the area while chital alone contributed more than 58% of the total prey biomass available for the tiger. Muntjac (1.5%) contributed the lowest portion of prey biomass available for the tiger in the study area.

Table 6.12: Density and biomass of tiger prey species in buffer zone of the Corbett Tiger Reserve

S. No.	Species	Density (Ind./km^2)	Weight (kg)	Biomass (kg/km^2)
1	Chital	33.6	55	1848
2	Sambar	4.4	212	932.8
3	Muntjac	2.4	20	48
4	Wild pig	2.3	38	87.4
5	Nilgai	0.5	184	92
6	Langur	26	9	128.8
7	**Total**			**3137**

3.4.3 Block-wise abundance of prey species (Forest department census data)

Block-wise densities of different prey species in buffer zone of the CTR were calculated from Forest Department's data and these values were used to categorize forest blocks as having low, medium and high densities of prey species. The data were also used to calculate total area of forest blocks under each category (Tables 6.13 and 6.14).

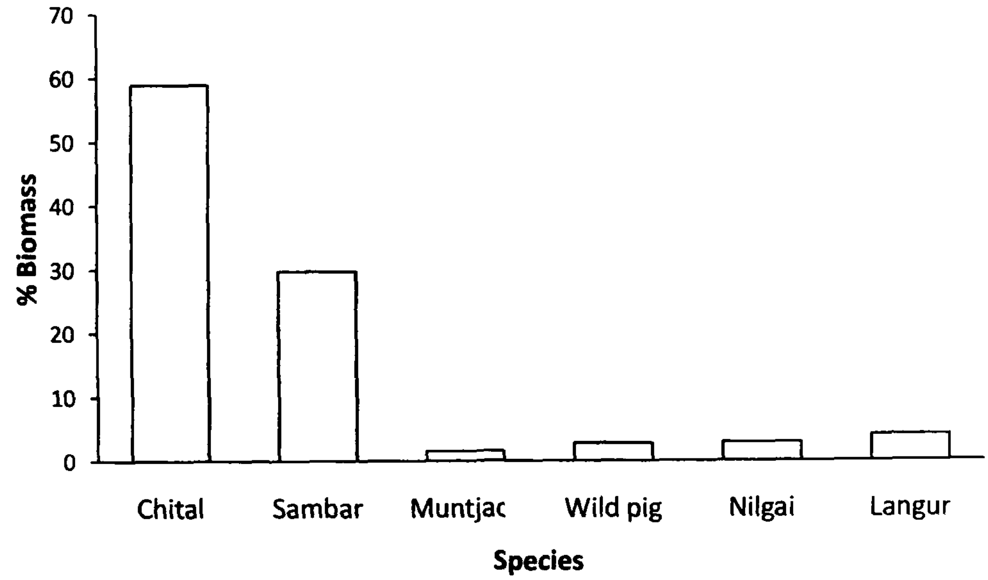


Figure 6.15: Biomass of different tiger prey species in buffer zone of the Corbett Tiger Reserve

3.4.3.1 Density

Chital: The overall chital density estimated from forest department data was 7.5 chital/km^2. Chital was present in low density in 92% of the 26 forest blocks of the buffer zone. Out of the remaining 2 blocks, 1 had medium density and 1 had high density, both blocks were located in the southeast of the buffer zone (Map 15 and Appendix V).

Sambar: The overall sambar density, estimated from forest department data, was 1.7 sambar/ km^2. While sambar were present in low density in most of the forest blocks of the buffer zone (65%), spatially most of these blocks were in the north of the buffer zone. Sambar was present in medium density only in two of the blocks (7.6%), which were located in the southern portion of the buffer zone. Three of the blocks (11.5%) with high sambar density were located in the southeast of the buffer zone (Map 16 and Appendix V).

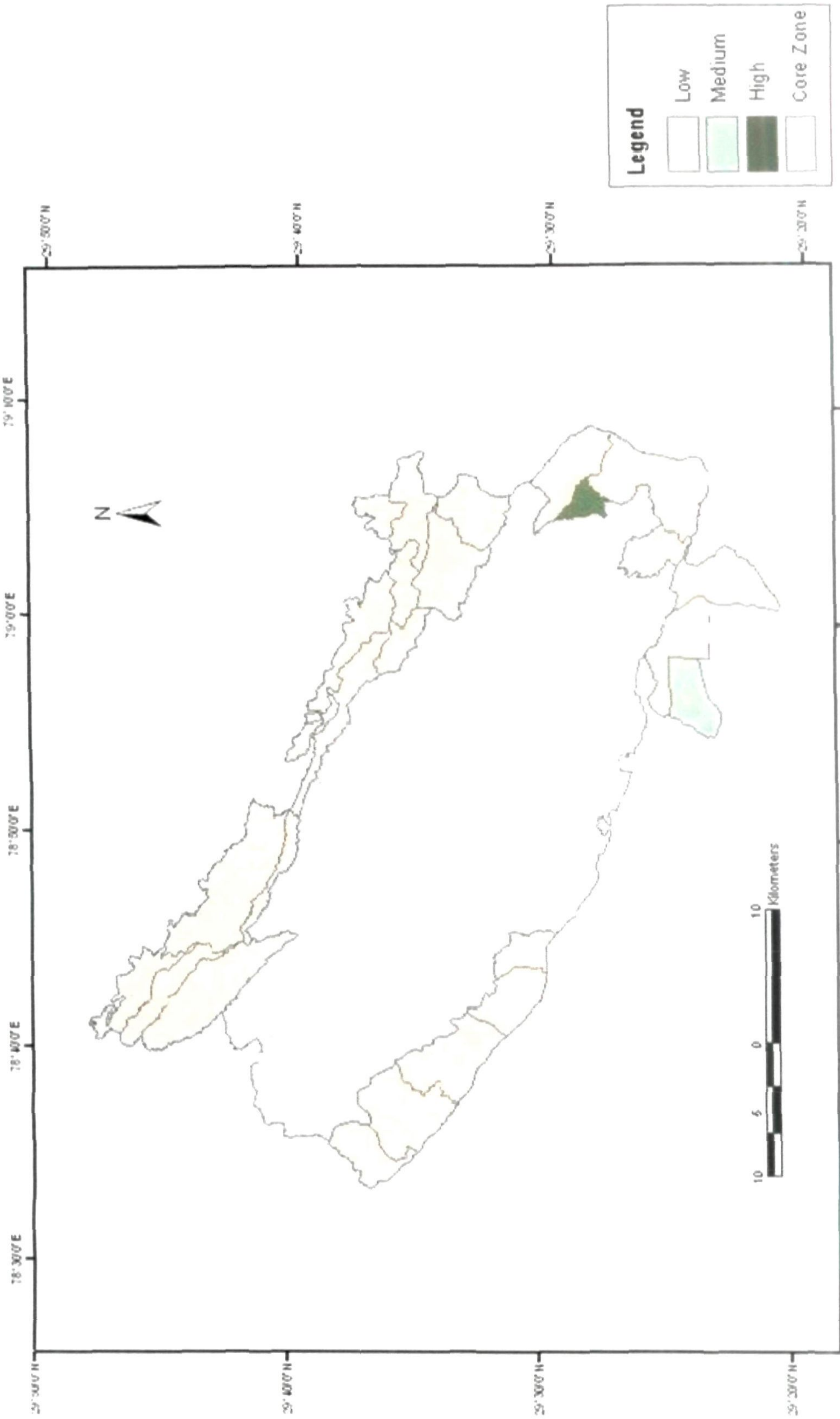
Muntjac: The overall muntjac density estimated from forest department data was 0.6 muntjac/km^2. While 50% of the forest blocks of the buffer zone had low density of muntjac, spatially these blocks were spread all over the buffer zone. The species was found in medium density in 19% of the forest blocks, most of which were in the south of the buffer zone, with only one block in the north under this category. Muntjac was found in high density in 23% of the blocks, which were located only in the eastern portion of the buffer zone. The remaining 2 blocks (7.6%) had no presence of muntjac and were located in the north of the buffer zone (Map 17 and Appendix V).

Table 6.13: Number and percentage of forest blocks having low, medium, high densities and total biomass of prey species (Forest Department data)

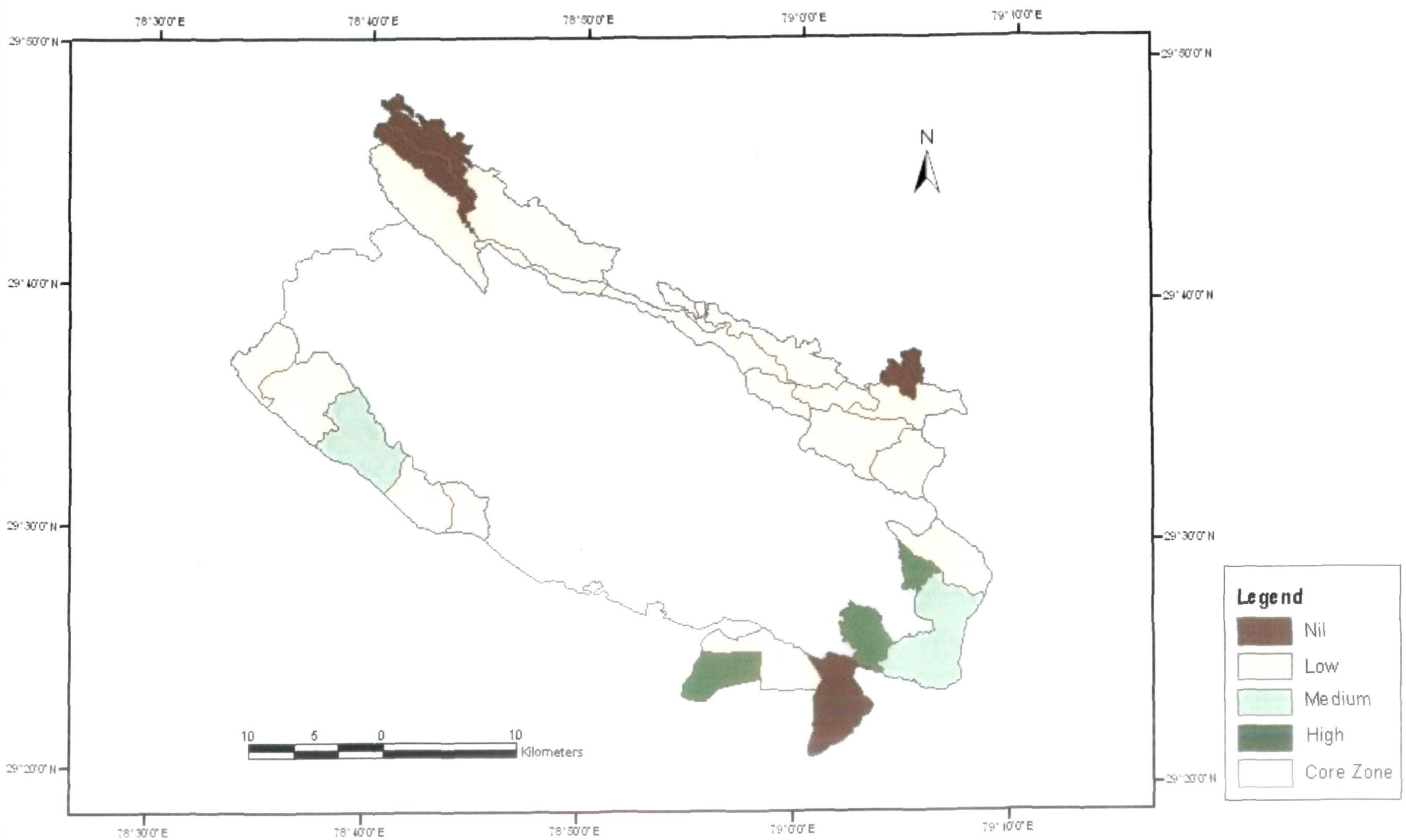
Prey species	Number of blocks under each density category (%)			
	High	**Medium**	**Low**	**Nil**
Chital	1 (3.5)	1 (3.8)	24 (92.3)	0 (0)
Sambar	3 (11.5)	2 (7.7)	17 (65.3)	4 (15.4)
Muntjac	6 (23.1	5 (19.2)	13 (50)	2 (7.7)
Wild pig	3 (11.5)	6 (23.1)	15 (57.6)	2 (7.7)
Total biomass	2 (7.7)	2 (7.7)	22 (84.6)	-

Table 6.14: Block area under different categories of densities of prey species and biomass availability in the buffer zone of Corbett Tiger Reserve (Hectares)

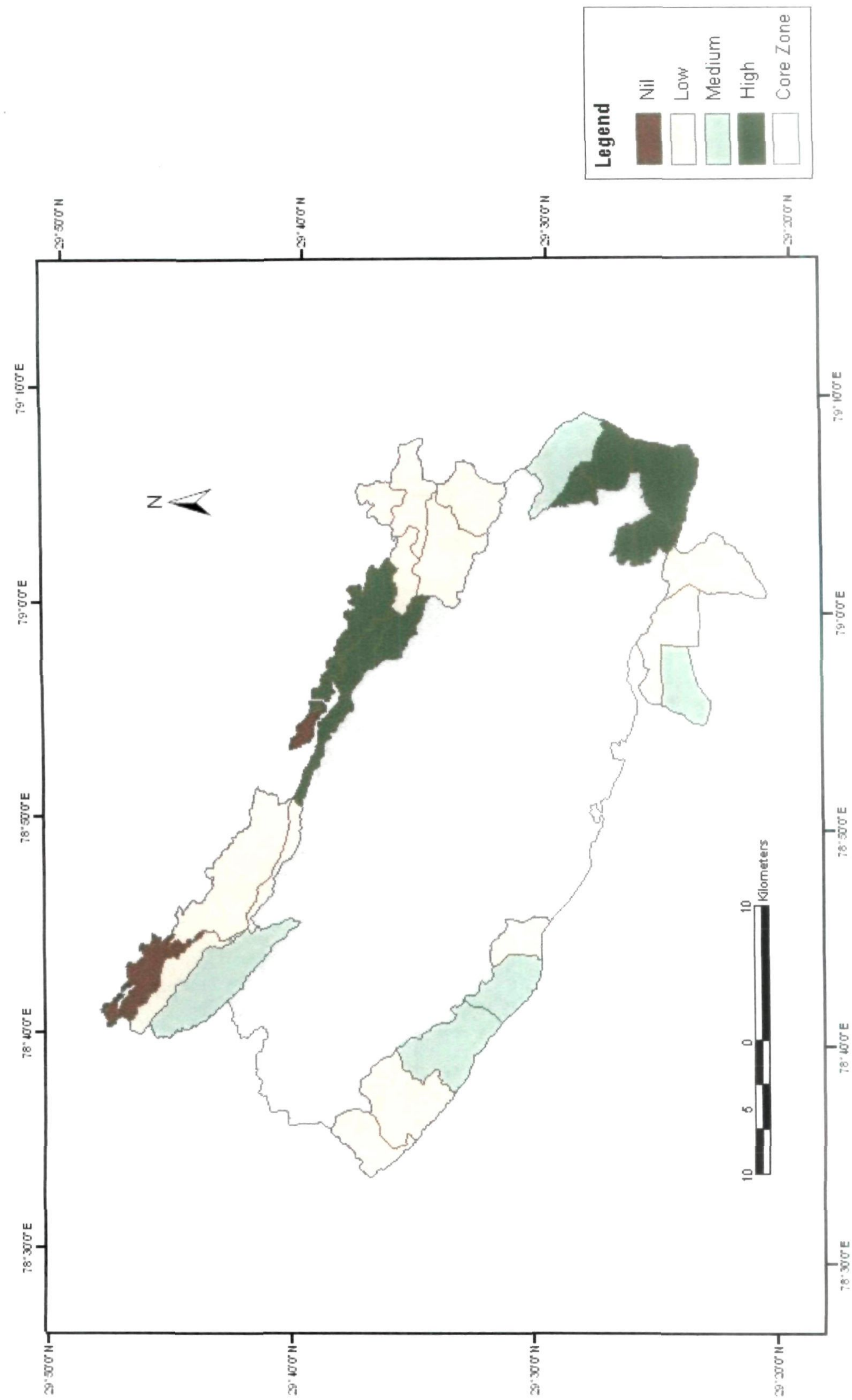
Prey species	Nil	Low	Medium	High
Chital	0	44625.2	1465.3	667.3
Sambar	6163.8	31011.1	6207.5	3375.4
Barking deer	1822.7	23092.7	11350.2	10492.2
Wild pig	2344.8	30381.0	10656.6	3375.4
Total prey biomass	0	39827.2	4798.0	2132.6



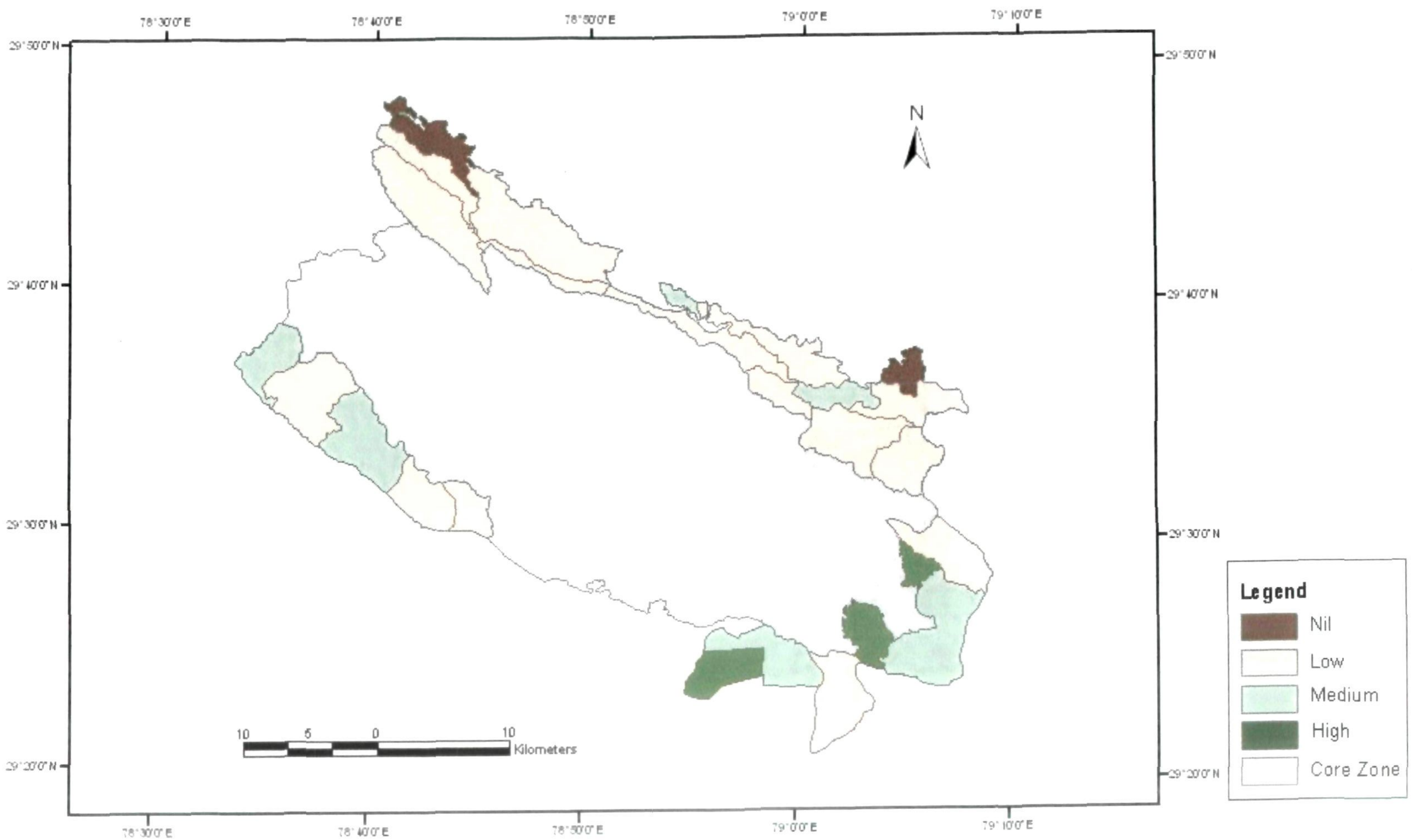
Map 15: Density of chital in forest blocks of the buffer zone of the CTR



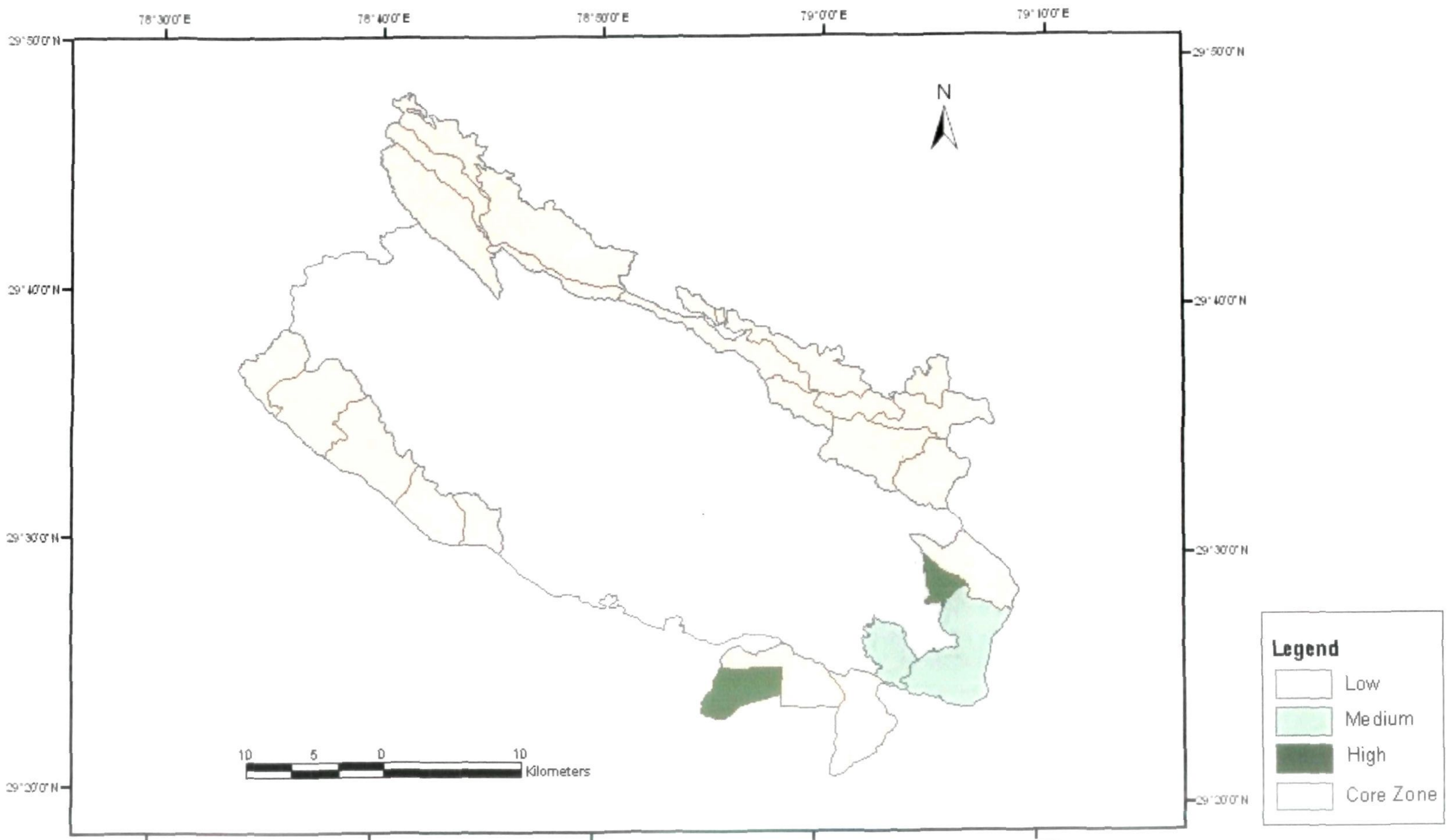
Map 16: Density of sambar in forest blocks of the buffer zone of the CTR



Map 17: Density of muntjac in forest blocks of the buffer zone of the CTR



Map 18: Density of wild pig in forest blocks of the buffer zone of the CTR



Map 19: Block-wise availability of prey biomass in forest blocks of the buffer zone of the CTR

Wild pig: The overall wild pig density estimated from forest department data was 2.9 wild pig/km^2. Wild pig were present in low density in 57% of the forest blocks of the buffer zone, most of which were located in the northern portion of the buffer zone, with only 4 blocks in the southern region. Another 23% of the blocks had medium density of wild pig. Most of these forest blocks were in the southern portion of the buffer zone, with only 2 blocks, which were also comparatively very small in terms of area, in the north of the buffer zone. Of the remaining blocks, 3 (11.5%) had high density of wild pig and 2 (7.6%) had no presence of the animal. While the blocks with high density were located in the southern portion of the buffer zone, the latter were located in the northern portion of the buffer zone (Map 18 and Appendix V).

3.4.3.2 Biomass

While 84% of the forest blocks, located mostly in the north of the buffer zone, had low prey biomass availability, 7.6% had medium prey biomass availability and an equal percentage had high availability of prey biomass. These blocks were located in the east of the buffer zone (Map 19 and Appendix 19)

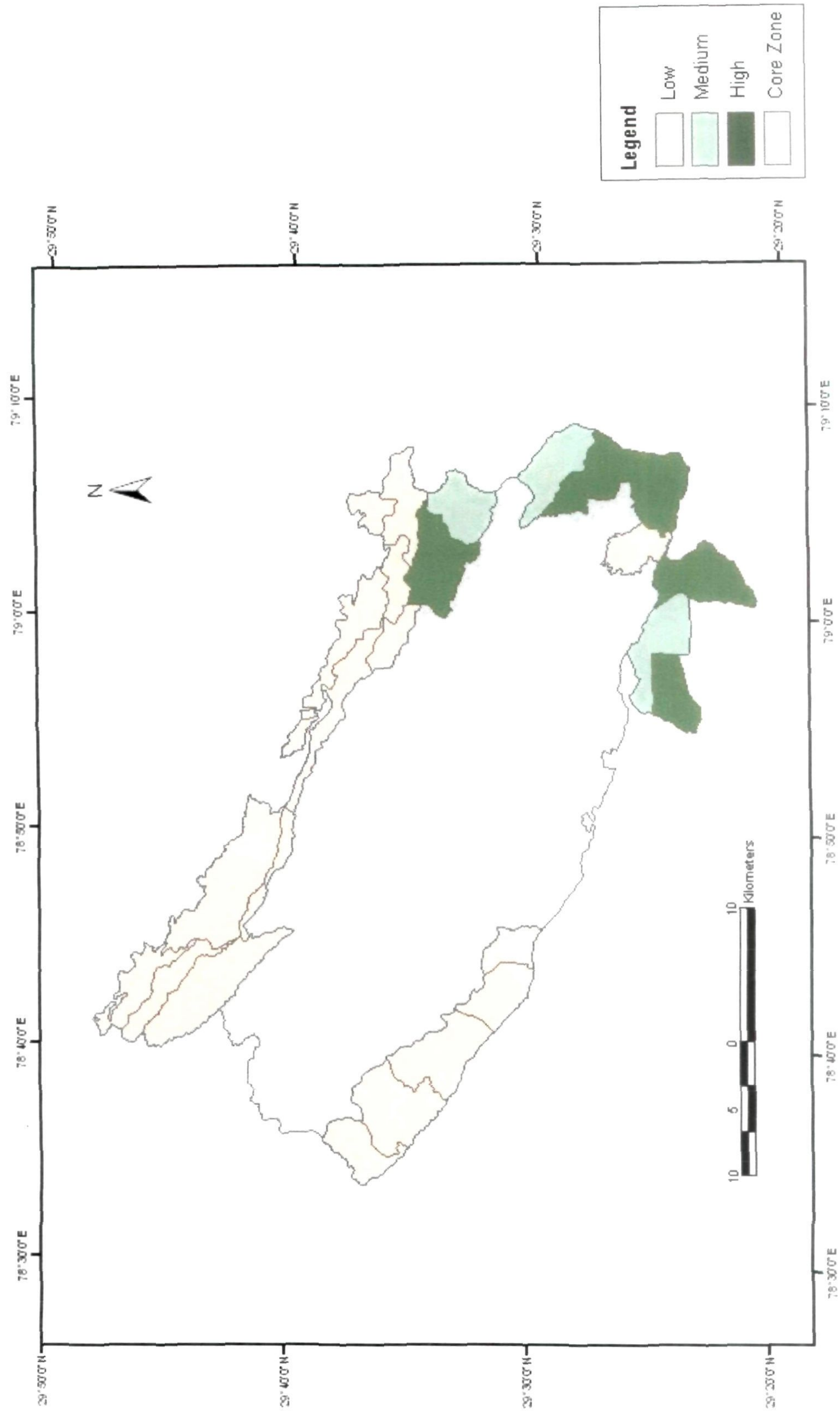
3.4.4 Pellet group density

Table 6.15 provides the values of pellet group densities of different ungulate species found in different forest blocks of the buffer zone of the CTR. The area under each density category is given in table 6.16.

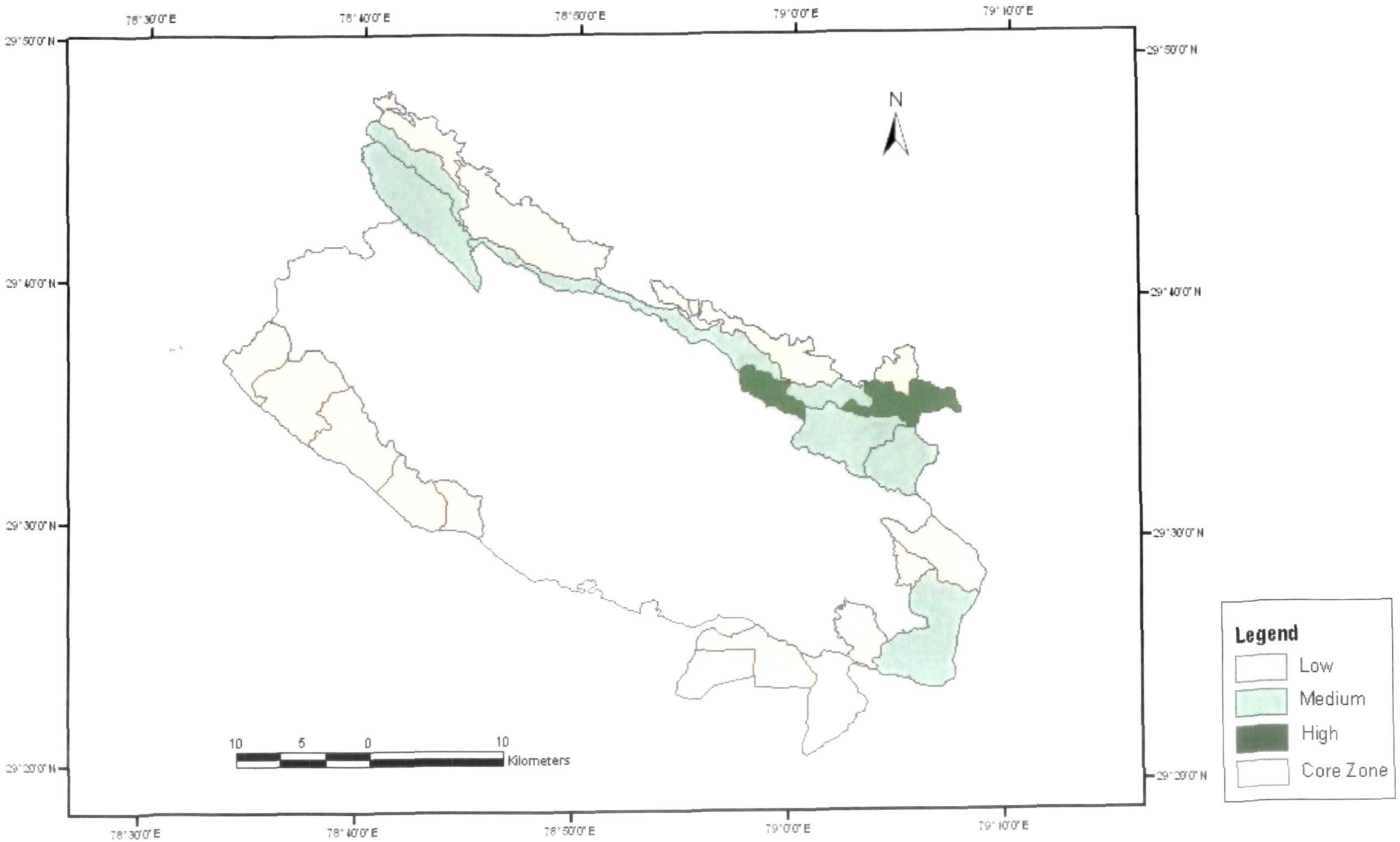
Chital: The overall pellet group density for chital was 36.5 pellet groups/ha and it varied significantly between different blocks (K-W One Way ANOVA χ^2 = 818, d.f. = 25, P<0.001). Most of the forest blocks (69%) in the buffer zone had low density of chital pellet groups. These blocks were located in the north and southwest of the buffer zone, except for one block, which was located in the southeast of the buffer zone. Out of the remaining blocks, 19% (5) had high pellet group density while 11.5% (3) had medium density. Both the high and medium density blocks were located in the southeast of the buffer zone (Map 20 and Appendix VI).

Table 6.15: Pellet group densities (number of pellet groups/ha) of prey species in the forest blocks of the buffer zone of the Corbett Tiger Reserve

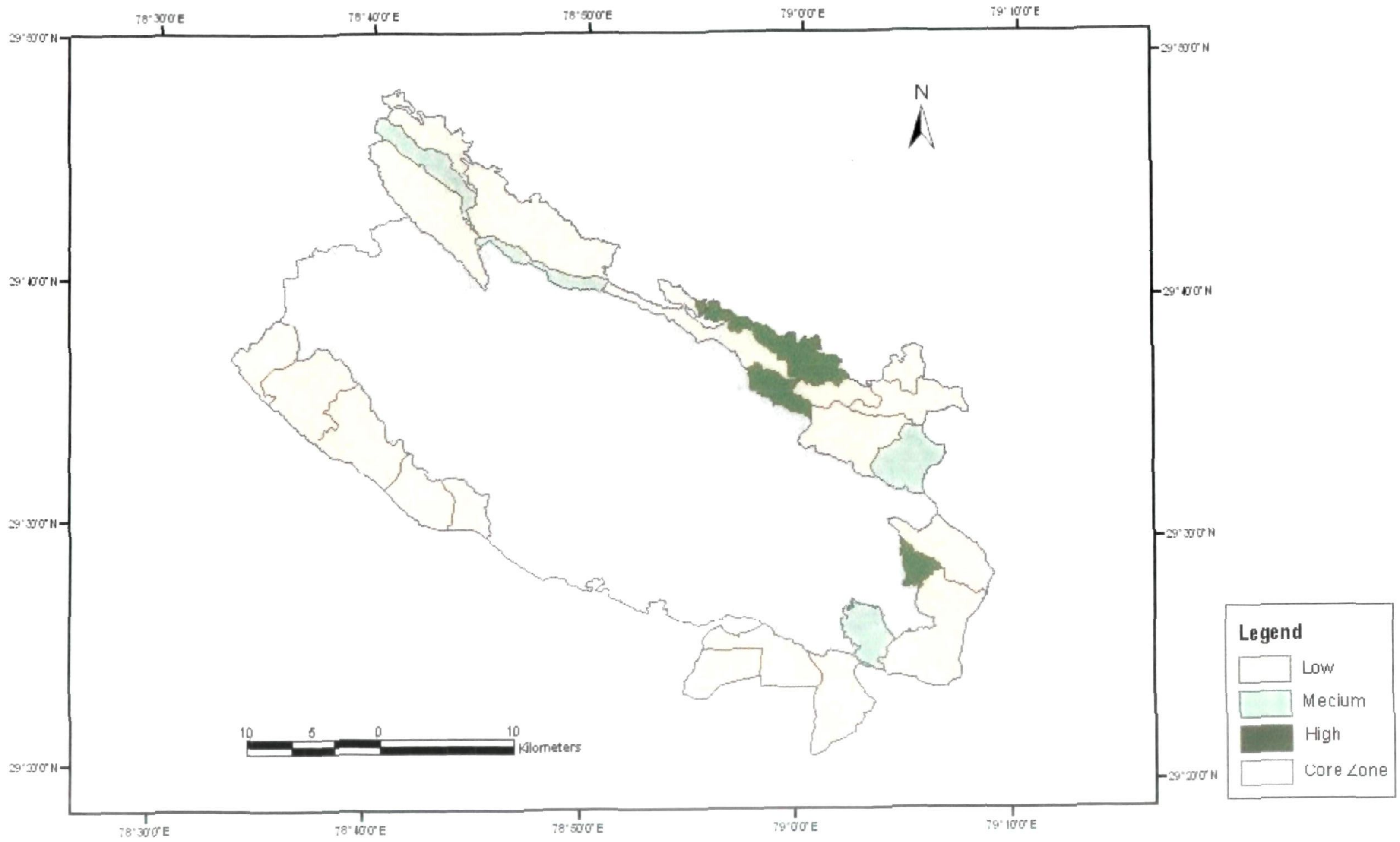
Block name	Chital	Sambar	Muntjac	Wild pig	Nilgai
Adnala	0	54.1	12.7	15.9	0
Bijoragadh	0	7.2	5.6	1.9	0
Dhaulkhand	30.1	11.3	0.2	0.2	5.3
Dhela Bhabar	103.2	19.5	8.2	11.5	8.8
Dhulwa (E)	52.2	10	2.6	0.6	0
Dumunda (E)	68.1	44.7	12.4	0.9	0.9
Dumunda (W)	103.9	67	3.3	1.2	0
East Mandal	3.2	27.1	19.1	3.2	0
Era	17.5	34.2	3.9	2.4	0
Haldgaddi	1.4	7.8	2.1	1.4	0
Jamaria (W)	28.4	99.5	5.4	0	0
Kalagadh	3.9	17.3	2.7	2.7	18.6
Kalakhand	0	48.4	1.3	7	0
Kalushaheed	5.4	8.9	0.5	0.2	1.7
Kartia	0	3	6.1	4.5	0
Khansur	3.3	57.3	6.4	0.2	0
Kugadda	1.6	55.7	12.7	5.8	0
Lohachaur	0	126.4	27.9	0	0
Malani	93.3	9.9	21.9	3.3	0
Mandal	3.2	60.5	7.9	1.6	0
North Jashpur	124.2	14.6	0.4	11.3	2.6
Nalkatta	8.9	20.2	1.9	5.4	36.9
Pakharau	3.2	50.9	0	0	0
Phooltal	166.8	45.5	8.3	13.3	0.5
Sanwalde Bhabar	113.2	31.8	0.9	4.3	16.4
Sanwalde Hill	14.3	12.7	11.2	1.6	0
Overall	36.5	36.3	7.1	3.9	3.5



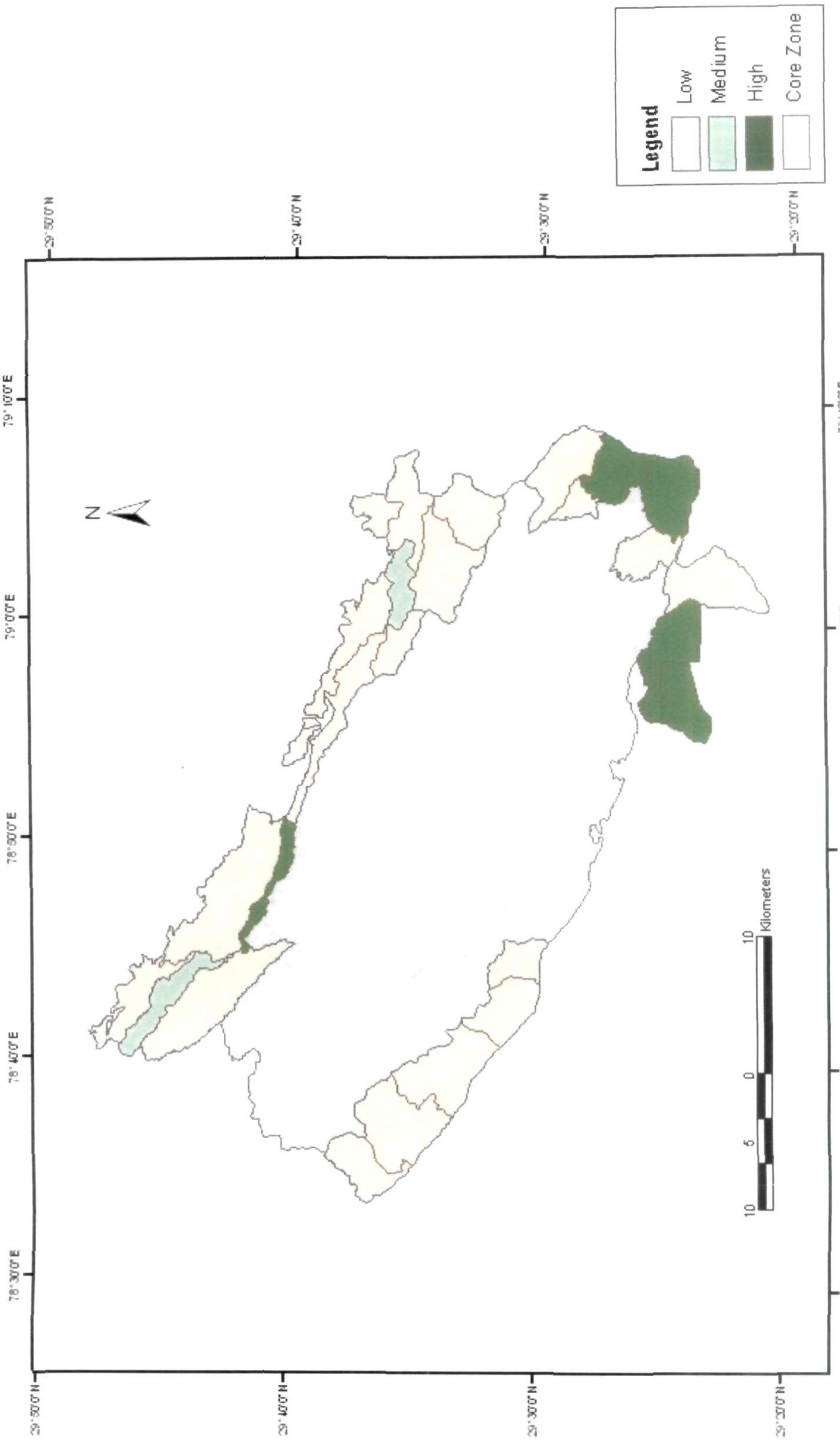
Map 20: Pellet group density of chital in forest blocks of the buffer zone of the CTR



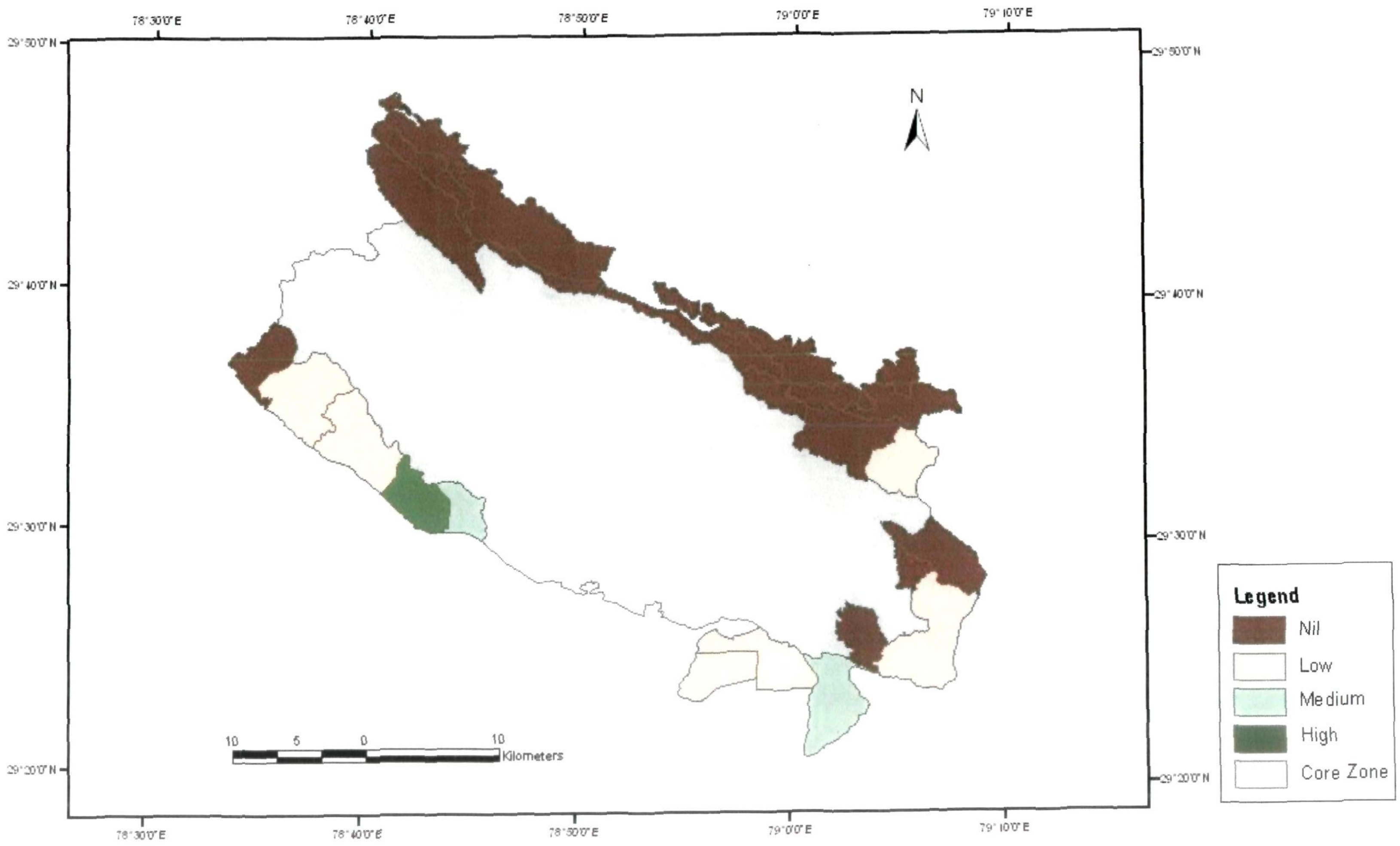
Map 21: Pellet group density of sambar in forest blocks of the buffer zone of the CTR



Map 22: Pellet group density of muntjac in forest blocks of the buffer zone of the CTR



Map 23: Pellet group density of wild pig in forest blocks of the buffer zone of the CTR



Map 24: Pellet group density of nilgai in forest blocks of the buffer zone of the CTR

Table 6.16: Block area under different categories of pellet group densities of prey species in the buffer zone of the Corbett Tiger Reserve (Hectares)

Prey species	Nil	Low	Medium	High
Chital	0	30170.8	5856.1	10730.9
Sambar	0	27808.8	16206.4	2742.6
Muntjac	0	37712.9	5246.3	3798.6
Wild pig	0	36901.9	2074.0	7781.9
Nilgai	27916.0	14203.4	2986.5	1651.9

Sambar: The overall pellet group density for sambar was 36.3 pellet groups/ha and it varied significantly between different blocks (K-W One Way ANOVA χ^2 = 358, d.f. = 25, P<0.001). While 61.5% of the blocks had high sambar pellet group density, 30.7% (8) had medium density and 7.6% (2) had high density. While the blocks with low density were mostly located in the southern portion of the buffer zone, most of the medium and high density blocks were in the northern portion of the buffer zone, with only one medium density block located in the southeast of the buffer zone (Map 21 and Appendix VI).

Muntjac: The overall pellet group density for muntjac was 7.1 pellet groups/ha and it varied significantly between different blocks (K-W One Way ANOVA χ^2 =198, d.f. = 25, P<0.001). Majority of the forest blocks (73%) had low pellet group density of muntjac. These blocks were located across the buffer zone, mostly in the southern portion of the buffer zone. Of the remaining blocks, 15% (4) had medium density. These were located in the north and southeast of the buffer zone. High density of muntjac pellet groups was found in 11.5% (3) of the blocks. These were located in the northeast and east of the buffer zone (Map 22 and Appendix VI).

Wild pig: The overall dropping density for wild pig was 3.9 droppings/ha and it varied significantly between different blocks (K-W One Way ANOVA $\chi^2 = 147$, d.f. = 25, $P<0.001$). Low dropping density of wild pig was found in 76.9% of the forest blocks of the buffer zone. Most of the blocks in this category were located in the northern and southwest portions of the buffer zone. 7.6% (2) of the forest blocks had medium and 15% (4) had high dropping density. While both the blocks with medium density of wild pig droppings were located in the northern portion of the buffer zone, most of the blocks with high density of wild pig droppings were located in the southeastern portion of the buffer zone (Map 23 and Appendix VI).

Nilgai: The overall pellet group density for nilgai was 3.5 pellet groups/ha and it varied significantly between different blocks (K-W One Way ANOVA $\chi^2 = 392$, d.f. = 25, $P<0.001$). In comparison to other prey species majority of the forest blocks (65%) had no indirect evidence of nilgai. These forest blocks were mostly located in the northern portion of the buffer zone. 23% of the blocks, mostly located in the southern portion of the buffer zone had low pellet group density of nilgai. 7.6% of the blocks with medium pellet group density were located in the south of the buffer zone. The single block which had high pellet group density, was located in the southwestern portion of the buffer zone (Map 24 and Appendix VI).

The encounter rates of different prey species in different forest blocks and the density of prey species in corresponding blocks of buffer zone of the CTR did not show any significant correlation. However, the encounter rate of chital was found to be significantly positively correlated with chital pellet group density ($r = 0.765$, d.f. =10, $P<0.01$). The encounter rates for other ungulate species were found to be not correlated with their corresponding pellet group densities. The pellet group densities and animal densities calculated from the forest department data showed significant correlation for barking deer ($r = 0.455$, d.f. = 25, $P<0.05$) and nilgai ($r = 0.754$, d.f. =25, $P<0.01$) only. The pellet group densities and animal densities for other species, however, did not show any significant correlation.

3.4.5 Grouping tendencies of tiger prey species

Group composition and grouping tendencies play very important role in the predator-prey relationship. Grouping tendencies of prey species are evolved in response of the resource availability and predation pressure. Table 6.17 provides the mean group size of different prey species with mean group size of different age categories of prey species of tiger.

Table 6.17: Mean group size for different age and sex categories of tiger prey species in the buffer zone of the CTR

Category	Chital	Sambar	Muntjac	Nilgai	Wild pig
No. of obs.	420	146	111	26	52
Pooled	4.83	2.14	1.09	3.34	2.38
AM	2.07	1.08	1.03	1.14	1.16
YM	1.42	1	1		
AF	3.17	1.71	1	3.5	1.87
YF	2.11	1.08			
FN	1.88	1.21		1.4	2.78

Chital: During the study period 420 groups of chital were classified and group size of chital was varied from the 1 to 48 individuals. Mean group size for the chital was 4.83±0.10. Among the tiger prey species, chital appeared most gregarious species. Small group (1-5 individuals) appeared most common group size in chital and contributed 72.1% of all the chital groups, followed by medium size (6-10) contributing 18.1% whereas large groups (>10) contributed only 9.8% of total groups of chital recorded during the study period.

Sambar: A total of 146 groups of sambar were classified and group size of sambar was varied from 1 to 9 individuals. Mean group size of sambar was 2.14±0.10. Small group size (1-2 individuals) appeared most common group size for sambar and contributed 74.7% of all the sambar groups, followed by medium group size (2-4 individuals) contributing 16.4% whereas the large group size (>4) contributed only 8.9% in the total groups of sambar recorded during the study.

Muntjac: Since there was no significant variation in the group size of muntjac and mostly either single individual or two individuals and only once three individuals were recorded during the study period. Muntjac appeared least gregarious species among the tiger prey species in the study area. Groups of Muntjac were classified into single, pair and >2 individuals. During this study 111 groups of muntjac were recorded, out of which only 7.2% groups had more than one individual and 0.9% groups had >3 individual. Mean group size of muntjac was 1.09±0.03. Solitary individual appeared most common and contributed 91.9% of total groups sighted during the study period.

Nilgai: During the study, 26 groups of nilgai were classified and group size of nilgai ranged from 1 to 12 individuals. Mean group size of nilgai was 3.34±0.54. In case of nilgai also, the small group size (1-2 individuals) appeared most common and contributed 50% to the all groups of nilgai, followed by large group (>4 individuals) contributing 30.8%. Medium groups (3-4 individuals) contributed 19.2% to the all groups of nilgai recorded during this study.

Wild pig: During the study, 52 groups of wild pig were classified and group size varied from 1 to 9 individuals. Mean group size of wild pig was 2.38±0.27. Like all species, small group (1-2 individuals) was appeared most common group size and contributed 67.3% of all the groups of wild pig recorded during this study. Medium groups (3-4 individuals) contributed only 17.3% whereas large groups (>4 individuals) contributed 15.4% to the all the groups of wild pig.

3.4.6 Population structure

Chital: During the study, 81% of total individuals of chital encountered in the field were classified and rest of the individuals (19%) were unclassified. Figure 6.16 showed the percentage of individuals in different age and sex categories for the chital in the study area. Sex ratio of chital was biased towards the females and there were 42 male to 100 females. The sex ratio of fawn to adult female was 27:100.

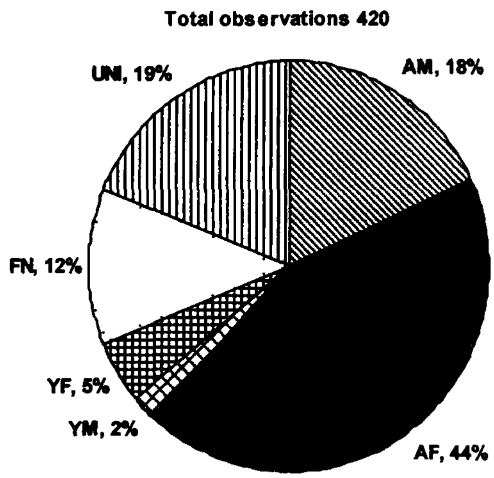


Figure 6.16: Percentage of individuals sighted in different age and sex categories for chital.

Sambar: During the study, 93% of total individuals of sambar encountered in the field were classified. Figure 6.17 showed the percentage of individuals in different age and sex categories for the sambar in the study area. Sex ratio of sambar was also biased towards the females and females were more in comparison of males (100:37). In comparison of only adult male and adult female, there were 39 males to 100 females. The fawn to adult female ratio was 24:100

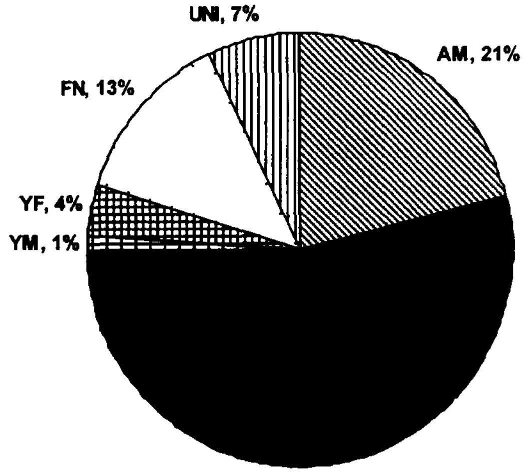


Figure 6.17: Percentage of individuals sighted in different age and sex categories for sambar.

Muntjac: During the study, 79% of total individuals of muntjac encountered in the field were classified and rest of the individuals (21%) were unclassified. Figure 6.18 showed the percentage of individuals in different age and sex categories. In muntjac too, sex ratio was biased towards the females and there were 61 males to 100 females.

Nilgai: During the study, 91% of total individuals of nilgai encountered in the field were classified and rest of the individuals (9%) were unclassified. Figure 6.19 showed the percentage of individuals in different age and sex categories. Sex ratio was biased in favour of females and there were 46 males per 100 females. Among the adult male and female sex ratio was 64 males per 100 females. Ratio of fawn to adult females was 14 fawns per 100 adult females.

Wild pig: During the study, 84% of total individuals of wild pig encountered in the field were classified and rest (16%) of the individuals were unclassified. Figure 6.20 showed the percentage of individuals in different age and sex categories. Sex ratio of wild pig was biased in favour of females and there were 84 males per 100 females. On consideration of only adult individuals, sex ratio was 84 males per 100 females. Adult female to fawns ratio was 100 adult females per 58 fawns.

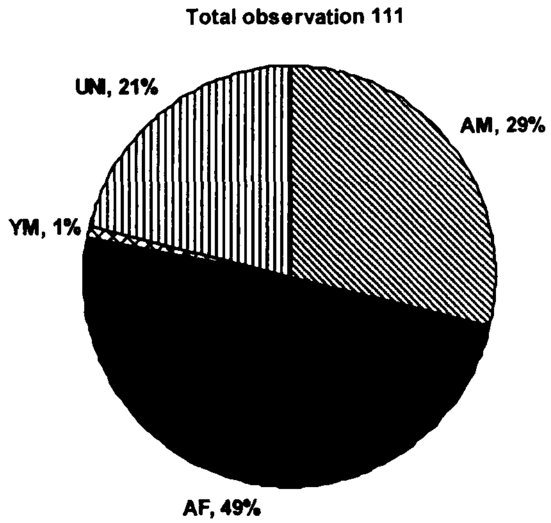


Figure 6.18: Percentage of individuals sighted in different age and sex categories for muntjac

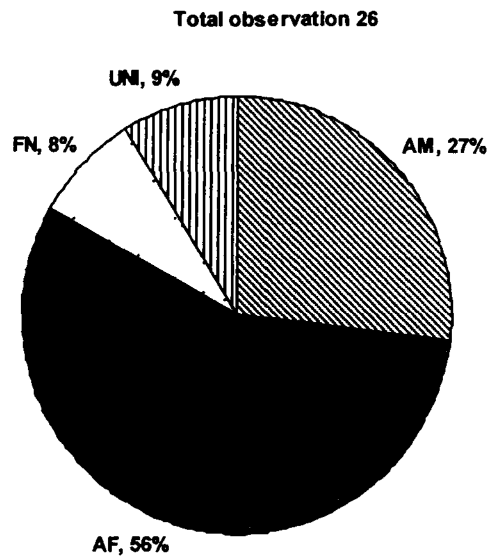


Figure 3.19: Percentage of individuals sighted in different age and sex categories for nilgai

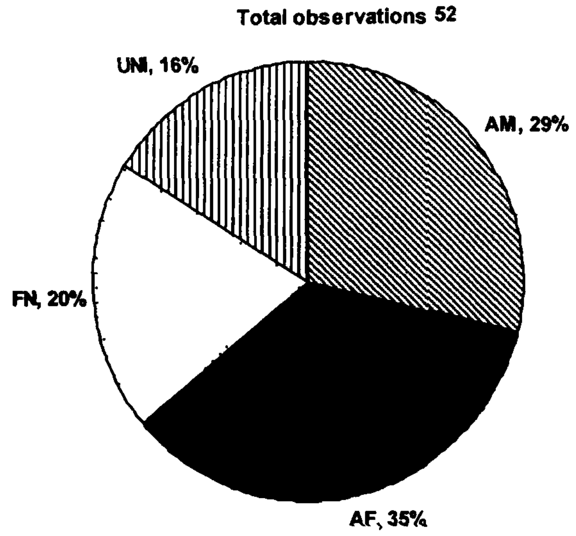


Figure 3.20: Percentage of individuals sighted in different age and sex categories for wild pig

3.5 Conclusion and discussion

3.5.1 Model selection based on AIC criteria

Akaike Information Criteria (AIC) was used to judge the fit of possible alternative models to each specific dataset. I accepted the selected model even if it had low or non-significant goodness-of-fit value (χ^2) following Buckland et al. (1993). However there were few exceptions in my dataset when I selected a model other than that having minimum AIC value. Analysis of data on all prey, sambar, muntjac, nilgai, wild pig during 2002-03 and langur during 2005-06 indicated that the best fit model (Hazard-rate) had low AIC value in comparison of other models. But the best model overestimated the density and reduced the ESW drastically, because of which the next best fit model was selected.

3.5.2 Density and biomass of prey species

Tiger distribution and ranging pattern can be controlled by prey species density and biomass availability (Sunquist 1981, Sunquist & Sunquist 1989). Prey densities estimated in the present study, when compared with those from other areas, it was found that density of chital was quite low in comparison of density in Gir, Pench, Kanha and Rajaji whereas it was close to Ranthambore, Mudumalai and Nagarhole (Table 6.18). But chital density is high in comparison of Bhadra, Chitwan and Bandipur. Estimates of sambar density are low in comparison of Rajaji, Ranthambore, Pench and Mudumalai whereas quite close to the Nagarhole, Gir and Bhadra. Since study was conducted in the buffer zone of the Corbett Tiger Reserve, the low density of chital and sambar might be because of high pressure of anthropogenic activities of local people and livestock grazing. Livestock species competed with prey species for resources and this competition is very high between the chital and livestock because both are sympatric in their grazing habits. Chital preferred the areas with flat terrain and same areas were preferred by local people to graze their livestock. Therefore, the pressure of livestock grazing has more pronounced effect on the population of chital in comparison to other prey species of tiger.

Estimated density of muntjac was quite low in comparison of Chitwan, Kanha and Nagarhole. The low density of muntjac might be because of biotic pressure and absence of muntjac from flat areas due to its preference for undulating terrain. Muntjac was not found in the southern most portion of the study area. Similarly the distribution of nilgai was limited to the southern portion of study area and was not found in the northern and eastern portion of study area. That's why estimate of nilgai density was low in comparison of Ranthambore and Rajaji. But the density estimates of wild pig was quite close to other areas which indicates that wild pig has the capacity to adapt areas having biotic pressure of human activities.

Table 6.18: Comparison of prey density in study area with other areas (Individual/km^2)

Location	Chital	Sambar	Muntjac	Nilgai	Wild pig	Langur
ISA (Buffer of CTR)	33.6	4.4	2.4	0.5	2.3	26
Pench (Karanth & Nichols 1998)	51.3	9.6		0.7	0.8	
Kanha (Karanth & Nichols 1998)	49.7	1.5	0.6	NP	2.5	
Bhadra(Karanth & Nichols 1998)	2.3	5.8	5.4		2.6	
Ranthambore (Karanth & Nichols 1998)	38.4	10.7		6.6	3.6	
NGH (Karanth & Nichols 1998)	38.1	4.2	6	NP	3.3	
BDP (Karanth & Nichols 1998)	20.1	5.6	0.7	NP	0.7	
MML (Varman & Sukumar 1995)	25.03	6.61		NP		
CTW (Seidensticker 1976)	17.3	2.9	6.7		5.8	
Gir (Khan et al. 1996)	57.3	3.5		0.58		
Chilla, Rajaji (Harihar et al. 2006)	41	24.7		2.8	2.4	19

Table 6.19: Comparison of prey biomass in study area with other areas

Location	Forest type	Biomass density kg km^{-2}
ISA (Buffer of CTR)	Tropical moist and dry deciduous	3137
Pench (Biswas & Sankar 2002)	Tropical dry deciduous	6013.3
Kanha (Schaller 1967)	Tropical moist deciduous	3902.3-4805.7
Nagarhole (Karanth & Sunquist 1992)	Tropical dry and moist deciduous	7638
Bandipur (Johnsingh 1983)	Tropical dry deciduous	3382-3619
Chitwan (Eisenberg & Seidensticker 1976)	Tropical moist with alluvial grassland	2933
Gir (Khan et al. 1996)	Tropical dry deciduous and thorn	3292
Ranthambore (Bagchi et al. 2004)	Tropical dry deciduous and thorn	6263
Kaziranga (Karanth & Nichols 1998)	Tropical moist with alluvial grassland	4252
Bardia (Dinerstein 1980)	Tropical moist with alluvial grassland	2842-3120
Chilla, Rajaji (Harihar et al 2006)	Tropical moist and dry deciduous	6083.7

The overall biomass estimated available (3117 kg/km^2) is less than Nagarhole, Ranthambore, Chilla range of Rajaji, Pench, Kaziranga, Kanha where estimated biomass varied from 3902.3 kg/km^2 to 7638 kg/km^2 but similar to value reported from Gir, Bandipur, Chitwan, Bardia, where estimated biomass was 3292 kg/km^2, 3500 kg/km^2, 2981 kg/km^2, 2933 kg/km^2 respectively (Table 6.19).

Block-wise abundance of prey species based on the Forest Department data showed that although 60% or more of the forest blocks had low prey species densities, the medium and high densities blocks were mostly located from east down to south of the buffer zone. More than 80% of the forest blocks also had low overall biomass mostly distributed in the north, while the blocks with medium and high prey biomass were mostly in the east of the buffer zone. Pellet group densities of prey species also showed a similar pattern to that of prey abundance distribution based on Forest Department data, except in the case of sambar, which had medium to high densities in the north of the buffer zone. Since the terrain of northern portion of CTR is more hilly in comparison of other areas and so it has low density of chital, in comparison of southern and eastern part and also nilgai is not found in the northern portion. Therefore the blocks located in the northern portion have low overall prey biomass available. Sambar shows its preference for hilly terrain, dense cover and absence of biotic pressure (Johnsingh 1983, Khan et al. 1990) thatswhy blocks located in northern part have medium to high pellet group density in contrast to other species which have low pellet group density in this area. Correlation of pellet group density with disturbance factors (Chapter 7) suggested that chital, nilgai and wild pig also utilized areas with moderate to high levels of disturbance whereas sambar and muntjac show clear avoidance for disturbed areas.

3.5.3 Grouping tendencies and population structure of prey species

Social organization of prey species play very important role in developing prey response mechanism to reduce the predation pressure and hence have the influence on the hunting success of predators (van Orsdol 1981). Hence, it is important to know group size and grouping tendencies of prey species to understand the ecological parameters of tiger ecology. Chital is most gregarious species and formed largest group followed by nilgai, wild pig and sambar whereas muntjac appeared least gregarious prey species and formed smallest group in the study area. Chital, nilgai and wild pig living more in open areas and tend to form large group to gain the advantage of better predator detection. Animals living in open areas tend to form large groups as an anti-predatory strategy (Varman & Sukumar 1993). Sambar and muntjac that relatively prefer forest with dense vegetation cover and show lesser degree of grouping tendencies as compared to other prey species. The statement is in accordance with the predator-avoidance hypothesis proposed by others (e.g. Dasmann & Taber 1956, Hirth 1977). In dense cover a single animal can be effectively concealed, whereas this concealing effect is lost with a large group (Varman & Sukumar 1993).

Comparison of chital mean group size (4.83) with other studies, revealed that mean group size is more than Pench (Biswas & Sankar 2002, MGS= 3.44) and Panna (Chundavat 2001, MGS=3.96) whereas it is less than in Nagarhole (Karanth & Sunquist 1992, MGS= 6.27), Gir (Khan et al. 1996, MGS= 5.6), and Chilla range of Rajaji (Harihar et al. 2006, MGS= 5.46). But the mean group size of sambar is more than these areas except the Chilla which has same mean group size as in the study area. This clearly indicated that the impact of biotic pressure in the buffer zone is more pronounced on the chital in comparison to sambar. Mean group size of nilgai (3.34) is more in comparison to Panna (2.8), Pench (1.75), Gir (1.9) and Chilla (1.95). Findings of study indicated the nilgai is able to tolerate impact of human disturbances and they can well thrive with the moderate presence of human activities. Nilgai lives relatively more near human settlements and therefore human activities do not have any impact on their ecology.

Pattern of grouping could be an indicator of poor resource availability and lack of habitat suitability, which could also have a negative impact on the reproductive success of the population (Jarman 1974). Highest percentage of groups encountered during the study belonged to the small group size for all the prey species. Similar pattern of highest groups in small group size was also reported in tropical forest of Nagarhole (Karanth & Sunquist 1992). Habitat available for prey species in the buffer zone is degrading in quality because of competition with livestock and human activities. Prey species are thus forced to form small groups.

Sex ratio of all the prey species was biased in favour of females. Similar biasness towards the females was recorded in Gir (Khan et al. 1995), Panna (Chundavat 2001) and Nagarhole (Karanth & Sunquist 1992). This biasness towards female sex might be primarily because of predation preference by carnivores towards the males. Males generally are big in size and have the habit of leading the group thus are more vulnerable to predation. In comparison to females, males show less alertness and also during rutting period males pay more attention on fight in comparison to detection of predator. Hence, predator crop more males in comparison to females and sex ratio thus get bias towards females. In chital population, number of fawns per 100 females was low in comparison of Nagarhole (Karanth & Sunquist, 1992) but it was more than in Panna (Chundavat 2001) and Gir (Khan et al. 1995). Low female to fawn ratio indicates the low reproduction in the prey species in the study area. This low productivity of prey species might be because of habitat degradation in the buffer zone of the CTR. Competition with livestock for the resources in the buffer zone also contributes to the productivity of habitat available for the herbivores in the buffer zone of the CTR.

HABITAT CONDITIONS AND HABITAT USE BY TIGER CHAPTER 7

7.1 Introduction

Major threats to tiger conservation include habitat loss, fragmentation, degradation, over harvesting of resources, poaching and conflict with the human interests. Out of these, habitat loss, fragmentation and degradation of habitat were primary factors behind extinction of tiger from larger part of its former range. About 4.5% of the India's geographical area is under protection for the conservation of biological diversity. Through the protection, the basic needs i.e. food, water and shelter, for the wild animals in a habitat is ensured. These components should be sufficient in an ideal habitat to flourish wild animals without any human interference.

As the animal populations are directly or indirectly dependent on the vegetation, a scientific analysis and monitoring of vegetation in wildlife habitat forms an essential component in the management of wild animals (Khan 1993). The habitats are complex entities and are composed of number of interdependent habitat variables. Their occupancy by ungulate species is in a way a collective response to the spatio-temporal variation of such interdependent habitat variables (Norman et al. 1975) and therefore quantification of various habitat variables affecting distribution pattern of animals is crucial for their successful management.

The quality and character of the habitats significantly affects the fauna directly or indirectly depending on it. Abundance of herbivore species depend on the composition and characteristics of vegetation therefore indirectly quality of vegetation play important role in the conservation of carnivore species. But the anthropogenic activities, grazing of livestock and collection of fodder and fuelwood, of humans living in and around the tiger habitats put immense pressure on habitats and degraded available habitat. Impact of anthropogenic activities such as grazing of livestock, cutting, lopping and collection of fuelwood and fodder is appearing in the form of changes in structure, density and composition of vegetation. The consequence of grazing pressure become more obvious, where uncontrolled grazing by livestock, pose serious threat to habitat contiguity for wild animal (Silori & Mishra 2001). Each biotic pressure, having damaging impact on forest community dynamics (Pickett & White 1985, Whitemore 1991), has different effect on the subsequent development of vegetation (Loucks et al. 1980, Pandey & Singh 1985). Overgrazing alters the ecosystem function, structure and organization by reducing species richness and diversity, increasing the proportion of unpalatable weed species, accelerating soil erosion and depleting nutrient pool (Namdeo et al. 1989, Putman et al. 1989, Skarpe 1991, Pettit et al. 1995).

Knowledge of impact of these anthropogenic activities on the tiger habitats is essential for the management of tiger habitats. Impact of biotic pressure depends on the extent of resource utilization by the local people living in and around available habitat of wild animals. Vegetation analysis of these degraded forest habitats would help in understanding the effect of disturbances on composition and dynamics of forest community. Understanding of vegetation characteristics, impact of biotic pressure, and corresponding habitat use by concerned species is central to design management strategies for the conservation of endangered species like tiger.

Tiger is a rare species living at low density in wild habitats. Successfully conserving a rare species depends on understanding interaction between the organism and its environment (Estes et al. 2008). Monitoring of condition of habitats used by the tiger provide valuable information required for the habitat management of tiger. Such information is also crucial for implementing management activities in the protected areas for the long-term conservation. Therefore, systematic study of habitat conditions, habitat use and other component of vegetation is crucial to achieve desired conservation goals.

7.2. Methodology

7.2.1. Habitat conditions and disturbance factors

Data collection: Quantification of the various habitat parameters and disturbance factors was done by laying sample plots, both on the permanent transects, as well as, in different blocks of the buffer zone of the Corbett Tiger Reserve.

(I) Transect sampling: Eleven of the 21 permanent transects were selected for collecting data on habitat structure and conditions. These 11 transects were selected on the basis of habitat type and topography. However, due to shortage of time and the start of monsoon, only nine transects could be sampled during the first phase of study period (Map 14). Circular plots of 10 m radius were laid at intervals of 100 m on the permanent line transects. At each sampling point, habitat type and topographical characteristics were noted. While tree layer was quantified in 10 m radius circular plots, shrubs were quantified in 3 m radius circular plots within the 10 m radius plots (Appendix VII). All tree and shrub species and their individuals were counted for density, diversity, and species richness and evenness estimation. The GBH (girth at breast height) of the trees was measured for estimating basal area and Importance Value Index (IVI) of the tree species. At every point the tree cover and shrub cover was also noted. The saplings and seedlings were counted in 1 m radius circular plots. Saplings and seedlings of all species and their individuals were counted for density and diversity estimation.

The ground layer was quantified in four 0.50 m X 0.50 m quadrates at each sampling point. Herb and grass species and their individuals were counted for density and diversity estimation of herbs and grasses. Data on disturbance factors viz., grazing, lopping, tree cutting, cattle dung piles and weed abundance were collected at each sampling point on an ordinal scale of 0 to 4 where, 0 represented no disturbance and 4 represented very high degree of disturbance such as severe grazing, heavy lopping and tree cutting (Table 7.1).

Table 7.1: Scores assigned for assessment of level of disturbance (for transect sampling data) in buffer zone of the Corbett Tiger Reserve

Category	Lopping and cutting (Number of trees affected)	Abundance of dung piles (Number of dung piles)	Grazing pressure (% of grass grazed)	Abundance of weeds (% of area covered by weed)
Nil (0)	0	0	0	0
Low (1)	1-2	1-3	>0-15	>0-25
Medium (2)	3-4	4-6	>15-30	>25-50
High (3)	5-6	7-9	>30-45	>50-75
Very High (4)	>6	>9	>45	>75

(II) Random Sampling: To quantify the forest blocks of the buffer zone in terms of biotic pressure, random sampling was done in all the 26 forest blocks in the buffer zone (Table 2.1). Random sampling plots were established at every 200 paces, in a random direction in all blocks of the buffer zone. At each sampling point, vegetation type, topography, tree cover, vertical structure, number of trees cut and lopped and number of livestock dung piles were recorded in 10 m radius circular plots. Shrubs were quantified in 3 m radius circular plots within the 10 m plots. While counting the shrubs and herbs, a separate distinction was made between individuals of *Lantana camara,* other weed species and general shrub and herb species, so as to differentiate between palatable and non-palatable shrub and herb species for the ungulates. A total of 1880 sampling points were laid across the 26 forest blocks.

Analysis: The habitat data collected on the permanent transects were used to calculate species density, diversity, richness and evenness and IVI for the tree layer as follows:

1. *Species density* (per hectare):

   D = (number of individuals of a species ÷ area of plot) X10000

Where, D = density,

area of plot = πr^2

2. *Species diversity index*: Species diversity is seen as an indicator of the well being of ecological systems (Magurran 1988). It is the number of individuals of each species present. *Shannon-Wiener* index was used for calculating the diversity of tree, shrub, herb, grass, and sapling and seedling species in the buffer zone.

The equation for the *Shannon-Wiener* diversity index (*H'*) is as follows:

$$H' = -\Sigma pi \ln pi$$

Where, *pi* may be defined as the proportion of individuals (n_i) found in the *i*th species out of total individuals (*N*) of all species. The value of the Shannon diversity (*H'*) is usually found to fall between 1.5 and 3.5 and rarely exceeds 4.5 (Magurran 1988).

Species richness: This is the total number of species found in any area (Magurran 1988).

3. *Evenness*: This is defined as equitable or even distribution of all individuals of the available species present in an area.

$$E = H' / \ln S$$

Where, *E* is the measure of evenness, and *S* is the total number of species. The value of *E* lies between 0 and 1.0 with 1.0 representing a situation in which all species are equally abundant (Magurran 1988).

All these indices were estimated with the help of computer software "Spec.div."

4. *Importance Value Index (IVI)*: Importance value index, which is sum of the relative frequency, relative density and relative dominance of a

species, was calculated to characterize the vegetation and reveal its dominance (Keel et al. 1993).

The IVI for all tree species were calculated as follows:

IVI = Relative frequency + Relative density + Relative dominance.

Where,

Relative frequency = (number of plots in which a species occurs ÷ total number of occurrence of all species) X100;

Relative density = (number of individuals of a species ÷ total number of individuals of all species) X100; and

Relative dominance = (basal area of a species ÷ total basal area of all species) X100.

Where, **Basal area = πr^2.**

The value of r was calculated from the GBH of individual trees as follows:

GBH = $2\pi r$, where $r = GBH \div 2\pi$.

For assessment of overall anthropogenic pressure on different transects, ordinal scores were assigned to the degree of disturbance in terms of cutting and lopping of trees, livestock grazing (cattle dung piles) and abundance of weeds (Table 7.1). The ordinal scores assigned to plots were then averaged for each transect. The mean scores for each transect were calculated as:

Mean score = (Sum of all the scores for a particular transect) ÷ (number of points sampled on a particular transect).

Data collected by random sampling in blocks were also used to assess anthropogenic pressure and degree of disturbance in blocks. The total number of cut trees, lopped trees and cattle dung piles for a particular block were divided by the number of points sampled in that particular block. This gave mean number of cut and lopped trees and cattle dung piles. On the basis of these mean scores blocks were ranked in low, medium and high level of disturbance categories (Table 7.2).

The Kruskal-Wallis One Way ANOVA test was used to determine the difference in species density, diversity, richness and evenness between different transects. It was also used to find out differences in biotic pressure intensity and disturbance levels in different blocks. The Pearson Product Correlation Coefficient and Spearman Rank Correlation Coefficient analysis were used to find out the correlation between various habitat factors, and disturbance factors using transect and block data. These tests were performed with the help of computer software SPSS.

Table 7.2: Assessment of block-level biotic pressure (for random sampling data) in Buffer Zone of the Corbett Tiger Reserve

Category	**Mean number of cut trees**	**Mean number of lopped**	**Mean number of dung piles**	***Lantana camara***	
				Percentage of plot under *L. camara*	**Derived mean score for a block**
Nil (0)	0	0	0	0	0
Low (1)	0.1-0.5	0.1-0.71	0.1-0.71	>0-20	0.006-0.6
Medium (2)	>0.5-1	>0.71-1.4	>0.71-1.4	>20-40	>0.6-1.2
High (3)	>1	>1.4-2.1	>1.4	>40	>1.2-1.8

7.2.2. Habitat use by tiger

Data collection: In order to understand the habitat utilization by tiger in the buffer zone of the CTR, the trails, roads, *nalas* (seasonal water body) and river beds were thoroughly surveyed and data on different habitat parameters were collected at the location where either a direct sighting of tiger or any indirect sign as scat, pugmark, scratch mark and urination site occurred. The survey area was categorized into eight major habitat types namely: Grassland, Mixed, Pure Sal, Sal mixed, Riverine, Riverbed, Scrub and Plantation. Different plantations like Teak plantation, Ailanthus plantation, Eucalyptus plantation and Shisham plantation were merged to a single category plantation.

Analysis: The Landuse/land cover map of survey area was prepared through the interpretation of the satellite imagery. The raw digital data of IRS I-C LISS III was obtained from NRSA and was subjected to radiometric correction using modified dark pixel subtraction technique as described by Chavez (1988). The image then registered geometrically using toposheets of Survey of India (SOI) on 1:50,000 scale. The mapping of forest cover and landuse in the study area was carried out using hybrid technique (visual and digital analysis of data).The supervised maximum likelihood classification technique was used to obtain Landuse/ land cover map using ERDAS Imagine version 8.7. The boundary of survey area was digitized from SOI topographic maps by co-registering the existing map of the forest department.

The available area under different habitat categories was calculated from generated landuse/land cover map using ERDAS Imagine version 8.7. This area was used to determine preference and avoidance of particular habitat by tiger. A chi-square goodness-of-fit test was used to determine whether the proportion of evidence of tiger per habitat differed significantly or to test the random selection of habitats by tiger.

To determine whether a particular habitat type was preferred or avoided by tiger, 95% *Bonferroni* confidence interval were calculated following Neu et al. (1974) and Byres et al. (1984). *Bonferroni* confidence interval was calculated by the following formula.

$$\overline{P_i} - Z_{a/2k}\sqrt{\overline{P_i}(1-\overline{P_i})/n} \le P_i \le \overline{P_i} \le Z_{a/2k}\sqrt{\overline{P_i}(1-\overline{P_i})/n}$$

where, $\overline{Pi}$ is the proportional usage of a habitat category *i* and *n* is the total number of used observations; $z_{a/2k}$ is the upper standard normal table value corresponding to a probability tail area of *a/2k*; *a* is the level of significance; *k* is the number of categories tested.

If expected proportional availability (*Pw*) of one habitat lies above the upper limit of the use confidence interval, then it is truly used less than expected and it is 'avoided' by animals; if its proportional availability lies below the use lower confidence interval, it is selected more than expected and it is 'preferred'. The preference and avoidance of a particular habitat was determined with help of computer based software PREFER.

7.3 Results

7.3.1 Habitat conditions

(I) Habitat characteristics

The buffer zone (study area) forest was dominated by *Shorea robusta* (Sal) along with its various tree species associates (Appendix VIII). The next most dominant species was *Mallotus phillippinensis*. Table 7.3 gives the IVI values of 10 most dominant species.

Table 7.3: Ten most dominant tree species and their Importance Value Indices (IVI) in the buffer zone of Corbett Tiger Reserve

Tree species (Local names)	Density/ha	IVI values
Shorea robusta (Sal)	54.8	98.2
Mallotus philippinensis (Rohini)	72.6	70.2
Tectona grandis (Sagon)	19.8	11.8
Ehretia acuminata (Khuda)	11.1	10.8
Diospyros exsculpta (Tendu)	9.5	10.3
Holoptelea integrifolia (Kanju)	11.1	8.4
Miliusa velutina (Dum Sal)	12.5	8.2
Lagerstroemia parviflora (Dhauri))	6.9	7.5
Haplopnragma adenophyllum (Kadhsagon)	10.9	6.3
Syzygium cumini (Jamun)	4.8	5.3

Ha = Hectare; IVI = Important value index

Table 7.4: Overall tree densities on the sampled transects in the buffer zone of the Corbett Tiger Reserve

Transect number	Density/ha	S.D.	S. E.
1	427.5	148.6	30.9
2	151.9	172.6	36.8
3	223.9	179.9	33.9
4	153.6	99.2	18.4
5	182.5	80.7	18.5
6	327.7	101.7	22.7
7	372.3	177.3	39.7
8	NS	NS	NS
9	NS	NS	NS
10	335.7	152.9	34.2
11	348.4	124.1	27.7
Total	273.9	171.3	12.1

Note: Only 11 of the 21 transects were sampled for habitat conditions.
Ha =Hectare; S.D. =Standard Deviation; S.E. =Standard Error; NS =Not sampled.

(II) Tree and shrub densities and diversity indices

Tree density: Tree density provides a good indication of the forest health. Table 7.4 summarizes the overall tree density on the 9 of the 11 transects sampled in the buffer zone of the CTR. Transect-1, located in Sal and mixed habitat (North Jashpur forest block) showed highest tree density (423.31/ha). Whereas, lowest tree density (151.85/ha) was recorded on Transect -2 which passed through mixed habitat and plantations (Dhela forest block). The mean tree density differed significantly between different forest blocks of the buffer zone (K-W One Way ANOVA χ^2= 311.12, d.f. = 25, P<0.01) and value of mean tree density ranged between 518.6 trees/ha to 124.6 trees/ha across different forest blocks (Table 7.5).

Table 7.5: Overall tree densities in sampled forest blocks of the buffer zone of the Corbett Tiger Reserve

Block number and name	**Mean density/ha**	**S.D.**	**S.E.**
1- Adnala	346.5	213.9	31.5
2- Bijoragadh	282.3	144.6	22.8
3- Dhaulkhand	252.1	103.5	9.9
4- Dhela Bhabar	124.6	71.4	14.5
5- Dhulwa (E)	243.6	117.0	12.9
6- Dumunda (E)	175.9	82.3	7.2
7- Dumunda (W)	273.3	158.7	14.0
8- East Mandal	227.6	144.3	14.2
9- Era	339.8	201.8	18.7
10- Haldgaddi	369.7	168.1	18.0
11- Jamaria (W)	209.7	137.1	8.8
12- Kalagadh	257.8	134.0	24.8
13- Kalakhand	312.7	123.6	14.1
14- Kalushaheed	260.4	66.2	8.2
15- Kartia	214.3	88.0	10.3
16- Khansur	269.2	126.2	15.6
17- Kugadda	302.2	138.9	17.9
18- Lohachaur	300.6	151.6	16.9
19- Malani	277.3	114.6	8.6
20- Mandal	262.4	102.1	22.8
21- N.Jashpur	276.8	117.7	26.3
22- Nalkatta	518.6	133.8	29.9
23- Pakharau	340.4	174.9	39.1
24- Phooltal	390.9	144.1	31.4
25-Sawaldeh Bhabar	318.1	70.3	22.2
26- Sawaldeh Hill	292.7	96.5	14.3

Ha = Hectare; S.D. = Standard Deviation; S.E. = Standard Error

Tree diversity indices: Table 7.6 summarizes tree diversity indices for buffer zone of the CTR. While Transect-10 had the highest richness (4.2), Transect-5 had the highest diversity (1.1) and evenness (0.8) values. However, Transect-1 had the lowest tree richness (2.4), while Transect-6 had the lowest diversity (0.5) and evenness (0. 4) values.

Significant differences were found across transects in terms of overall tree richness (K-W One-way ANOVA: χ^2 = 67.227, d.f. = 8, P<0.001,), diversity (K-W One-way ANOVA: χ^2 = 41.297, d.f. = 8, P<0.001,) and evenness (K-W One-way ANOVA: χ^2 = 39.202, d.f. = 8, P<0.001). The estimates of tree diversity, richness and evenness did not show any significant relationship with disturbance factors (P>0.05).

Table 7.6: Overall tree richness, diversity and evenness on transects in the buffer zone of the Corbett Tiger Reserve

Transect number	Richness	Diversity	Evenness
1	2.4	0.7	0.6
2	2.5	0.7	0.6
3	3.0	0.7	0.6
4	4.0	1.0	0.7
5	3.6	1.1	0.8
6	2.8	0.7	0.6
7	2.9	0.5	0.4
8	NS	NS	NS
9	NS	NS	NS
10	4.2	0.8	0.6
11	3.5	0.9	0.7

NS = Not sampled.

Shrub density: While highest shrub density (2297.63/ha) was recorded on Transect-11 which passed through plantations and mixed habitat type (Nalkatta forest block), the lowest shrub density (465.95/ha) was recorded on Transect-2 also located in plantations and mixed habitat type (Dhela forest block) (Table 7.7). Among the forest blocks of the buffer zone, highest shrub density (2773.47/ha) was recorded in block 14 and the lowest (377.85/ha) in block 12 (Table 7.8). Significant difference was found in shrub density across different forest blocks of the buffer zone (K-W One Way ANOVA χ^2 = 297.75, d.f. = 25, P<0.01).

Table 7.7: Overall shrub densities on the sampled transects in the buffer zone of the Corbett Tiger Reserve

Transect number	Mean density/ha	S.D.	S.E.
1	906.7	1075.4	224.2
2	465.9	854.6	182.2
3	1262.4	2005.2	378.9
4	706.9	1187.4	220.5
5	1525.5	1438.5	330.0
6	866.0	1041.5	232.8
7	583.2	576.5	128.9
8	NS	NS	NS
9	NS	NS	NS
10	2279.9	1868.6	417.8
11	2297.6	1523.6	340.6

NS = Not sampled; Ha = hectare; S.D. = Standard Deviation; S.E. = Standard Error.

Shrub diversity indices: Shrub richness was found to be highest for Transect -5 (3.631) and lowest for Transect-1 (1.226). However, while Transect-2 had the highest shrub diversity (0.941) and evenness (0.941), Transect-6 had the lowest diversity (0.324) and richness (0.416) (Table 7.9).

Table 7.8: Overall shrub densities in sampled forest blocks of the buffer zone of the Corbett Tiger Reserve

Block numbers*	Meandensity/Ha	S.D.	S.E
1	1014.3	935.5	137.9
2	1272.5	799.6	126.4
3	1688.8	1711.5	164.6
4	1325.5	1022.6	208.7
5	2474.3	1173.0	129.5
6	1734.7	1111.2	97.4
7	1310.9	1134.6	100.6
8	1170.2	1047.6	103.2
9	978.1	860.0	79.8
10	1243.2	1165.9	125.0
11	975.0	1084.5	70.0
12	377.8	462.1	85.8
13	1409.2	1091.4	125.1
14	2773.4	1537.2	190.6
15	1345.1	831.9	98.0
16	1321.4	1137.3	141.0
17	1855.7	1239.3	159.9
18	1886.7	1639.6	183.3
19	2183.8	1721.9	130.5
20	1360.9	516.3	115.4
22	1855.7	1196.6	267.5
21	2332.9	1247.9	279.0
23	1343.2	799.5	178.7
24	925.7	762.0	166.2
25	1060.4	816.3	258.1
26	1830.2	1288.4	192.0

**** For block names see table 2.1, Chapter 2; Ha = hectare; S.D. = Standard Deviation; S.E. = Standard Error.***

Table 7.9: Overall shrub richness, diversity and evenness on transects in the buffer zone of the Corbett Tiger Reserve

Transect numbers	Richness	Diversity	Evenness
1	1.2	0.5	0.7
2	2.6	0.9	0.9
3	2.6	0.5	0.5
4	1.7	0.6	0.7
5	3.6	0.9	0.7
6	1.2	0.3	0.4
7	2.0	0.7	0.8
8	NS	NS	NS
9	NS	NS	NS
10	2.2	0.8	0.7
11	2.4	0.8	0.7

NS = Not sampled.

Sapling and seedling densities: Table 7.10 gives the densities of saplings and seedlings on different transects. The sapling density was highest on transect-11 whereas seedling density was highest on transect-3.

(III) Herb density and diversity indices

While Transect-2 had highest mean herb density (75.6/m^2), it had the lowest herb richness (1.348), diversity (0.392) and evenness (0.376) values (Tables 7.11 and 7.12). Lowest herb density (4.3/m^2) was recorded for Transect-5, which however, had the highest herb evenness (0.854). Highest herb richness (5.279) and diversity (1.256) were recorded on Transect-7.

Table 7.10: Overall sapling and seedling densities on the sampled transects in the buffer zone of the Corbett Tiger Reserve

Transect number	Saplings			Seedlings		
	Density/Ha	S.D.	S.E.	Density/Ha	S.D.	S.E.
1	415.0	1456.2	303.6	22133.3	27893.9	5816.2
2	0.0000	0.0000	0.0000	6507.9	10998.7	2344.9
3	1590.8	3297.4	623.1	34089.3	61071.0	11541.3
4	2523.3	6552.5	1216.7	21613.4	51100.8	9489.1
5	2176.9	3975.6	912.0	33323.8	54009	12390.5
6	2068.0	3616.6	808.7	18135.5	19231.8	4300.3
7	954.5	1817.5	406.4	4136.1	3590.7	802.9
8	NS	NS	NS	NS	NS	NS
9	NS	NS	NS	NS	NS	NS
10	1113.5	1868.0	417.7	13203.9	17095.7	3822.7
11	3022.5	3340.9	747.0	10340.4	11159.7	2495.3

NS = Not sampled; Ha = Hectare; S.D. = Standard Deviation; S.E. = Standard Error

Table 7.11: Overall herb density on the sampled transects in the buffer zone of the Corbett Tiger Reserve

Transect numbers	Mean density/m^2	S.D.	S.E.
1	4.9	9.3	1.9
2	75.6	151.5	32.3
3	6.8	9.9	1.9
4	6.6	10.7	1.9
5	4.3	4.6	1.1
6	5.6	4.1	0.9
7	14.7	11.9	2.7
8	NS	NS	NS
9	NS	NS	NS
10	7.4	8.3	1.9
11	23.1	23.9	5.3

NS = Not sampled; Ha = hectare; S.D. = Standard Deviation; S.E. = Standard Error

Table 7.12: Overall herb richness, diversity and evenness on transects in buffer zone of the Corbett Tiger Reserve

Transect numbers	Richness	Diversity	Evenness
1	1.9	0.6	0.6
2	1.3	0.4	0.4
3	2.7	0.8	0.7
4	3.1	0.9	0.7
5	2.5	0.9	0.8
6	3.2	0.9	0.8
7	5.5	1.3	0.8
8	NS	NS	NS
9	NS	NS	NS
10	3.5	1.0	0.8
11	2.6	0.7	0.6

NS = Not sampled.

Table 7.13: Overall grass density on the sampled transects in buffer zone of the Corbett Tiger Reserve

Transect numbers	Density/m^2	S.D.	S. E.
1	30.6	25.2	5.3
2	39.3	35.8	7.6
3	23.8	17.3	3.3
4	53.2	42.5	7.9
5	10.2	9.0	2.1
6	12.7	11.5	2.6
7	9.1	9.7	2.2
8	NS	NS	NS
9	NS	NS	NS
10	7.2	12.6	2.8
11	7.9	12.8	2.9

NS =Not sampled; Ha =Hectare; S.D. = Standard Deviation; S.E. = Standard Error; NS = Not sampled

Table 7.14: Overall grass richness, diversity and evenness on sampled transects in the buffer zone of the Corbett Tiger Reserve

Transect numbers	Richness	Diversity	Evenness
1	0.6	0.4	0.5
2	1.0	0.4	0.4
3	0.3	0.4	0.9
4	0.5	0.5	0.7
5	1.3	0.8	0.9
6	1.9	0.8	0.8
7	0.9	0.5	0.7
8	NS	NS	NS
9	NS	NS	NS
10	2.4	0.9	0.8
11	1.4	0.7	0.7

NS = Not sampled.

(IV) Grass density and diversity indices

Highest grass density ($53.2/m^2$) was recorded on Transect-4 and the lowest ($7.2/m^2$) on Transect-10 (Table 7.13). As far as diversity indices were concerned, grass richness and diversity were highest (2.616 and 0.939 respectively) on Transect-10 while evenness was highest (0.902) on Transect-3 (Table 7.14). While lowest richness values were recorded for Transect-3 (0.307), lowest values of diversity (0.392) and evenness (0.376) were recorded for Transect-2 (Table 7.12).

7.3.2. Impact of disturbance factors on habitat

Anthropogenic activities leave their impact on forests in terms of lopping and cutting of trees, livestock grazing resulting in weed proliferation and loss of ground cover. Impact of resource utilization on the forest of buffer zone of the CTR was assessed. The mean scores of different disturbance factors on each transect were summarized (Table 7.15).

Table 7.15: Mean disturbance scores of sampled transects in the buffer zone of the Corbett Tiger Reserve

Transect numbers	Grazing	Dung piles	Cutting	Lopping	Weed abundance
1	1.7	0.1	1.4	1.3	1.7
2	1.9	0.9	0.7	0.6	2.6
3	1.3	0.5	1.1	0.9	1.7
4	1.4	0.6	1.1	1.7	2
5	0.1	0.1	0.6	0.4	1.2
6	0.1	0.1	0.1	0.3	1.3
7	0	0	0.3	0.2	1.3
8	NS	NS	NS	NS	NS
9	NS	NS	NS	NS	NS
10	0.6	0.5	0	1	1.2
11	0.6	0.5	0.3	0.9	1.4

NS = Not sampled.

Among the nine transects sampled, while Transect-2 showed highest degree of disturbance in terms of evidence of grazing (1.91), dung piles (0.96) and weed proliferation (2.64), Transect-1 (1.44) had highest cutting pressure and Transect-4 (1.68) had highest lopping pressure. While Transect-7 had no grazing pressure or presence of dung piles and also had lowest lopping pressure, Transect-10 had no tree cutting pressure. Weed proliferation was lowest on Transect-5.

The habitat types differed significantly in terms of grazing (K-W One Way ANOVA χ^2 = 34.35, d.f. = 8, P<0.01), lopping (K-W One Way ANOVA χ^2 = 21.2, d.f. = 8, P<0.01) and weed abundance (K-W One Way ANOVA χ^2 = 33.588, d.f. = 8, P<0.01). However no significant difference was found in terms of cutting pressure. The grazing pressure (K-W One Way ANOVA χ^2 = 61.81, d.f. = 2, P< 0.01), number of dung piles (K-W One Way ANOVA χ^2 = 17.23, d.f. = 2, P <0.01), lopping pressure (K-W One Way ANOVA χ^2 =

6.04, d.f. = 2, $P<0.01$), cutting pressure (K-W One Way ANOVA χ^2 = 14.49, d.f. = 2, $P<0.01$) and weed abundance (K-W One Way ANOVA χ^2 = 26.46, d.f. = 2, $P<0.01$) showed significant differences viz. a. viz topography type. The tree density showed negative correlation with grazing (r_s =-0.35), livestock dung abundance (r_s=-0.61), cutting (r_s=-0.17) and weed abundance (r_s=-0.40). However these correlations were not significant ($P>0.05$, N =9). The estimates of shrub density, diversity, richness and evenness, however did not show any significant relationship with grazing, livestock dung abundance, cutting, lopping and weed abundance ($P>0.05$). The herb density did not show any significant correlation with any of the disturbance factor. The livestock grazing was significantly negatively correlated with herb diversity (r_s =-0.80, N= 9, $P<0.01$), richness (r_s=-0.66, N= 9, $P<0.05$) and evenness (r_s = -0.71, N= 9, $P<0.03$). The livestock dung abundance was significantly negatively correlated with herb evenness (r_s = -0.68, N= 9, $P<0.04$). The weed abundance was significantly negatively correlated with herb diversity (r_s = -0.73, N= 9, $P<0.02$) and herb evenness (r_s = -0.81, N = 9, $P<0.01$). However, grass density showed significant positive correlation with grazing (r_s = 0.66, N = 9, $P< 0.05$), cutting (r_s = 0.81, N = 9, $P<0.01$) and weed abundance (r_s = 0.80, N = 9, $P<0.01$). The grass diversity and richness were significantly negatively correlated with cutting (r_s =-0.82 & -0.86, N = 9, $P<0.05$). The grass diversity was also negatively correlated with grazing (r_s = -0.71) and weed abundance (r_s = -0.81, N = 9, $P<0.01$). Sapling and seedling densities did not show significant correlation with any of the disturbance factors ($P>0.05$). Within the disturbance factors, the grazing pressure was found to be significantly positively correlated with livestock dung abundance (r_s = 0.82, N = 9, $P<0.01$), cutting (r_s = 0.67, N=9, $P<0.05$), looping (r_s = 0.71, N= 9, $P<0.05$), and weed abundance (r_s = 0.76, N =9, $P<0.01$). The weed abundance was positively correlated with livestock dung abundance (r_s = 0.79, N=9, $P<0.01$). The assessment of various disturbance factors on different transects did not show any significant correlation with assessment of various disturbance factors done in random block vegetation sampling ($P>0.05$).

Table 7.16: Mean disturbance scores in sampled forest blocks of the buffer zone of Corbett Tiger Reserve

Block numbers*	Cutting	Lopping	Grazing	Lantana abundance
1	0.2	0.7	1.1	0.3
2	0.2	0.6	0.5	0.5
3	0.5	0.6	0.03	0.3
4	0.1	0.8	1.7	1.2
5	1.7	1.3	1.1	0.6
6	0.3	0.8	0.6	0.5
7	0.2	0.6	0.7	0.5
8	0.4	0.6	0.9	1.3
9	0.9	0.7	1.4	1.8
10	1.3	1.5	1.5	0.2
11	0.5	0.6	0.3	1.1
12	0.1	0	0	1.3
13	0.1	0.1	0.01	0.4
14	0.1	0.01	0.03	0.3
15	0.4	0.3	0.02	0.9
16	0.5	0.4	0.1	0.3
17	0.8	1.7	1.1	0.2
18	0.9	1.2	0.8	0.4
19	0.3	1.2	0.6	0.01
20	0.8	2.7	3.1	1.5
22	1.1	1.4	0.5	0.5
21	0.3	0.3	0.4	0.8
23	1.2	1.9	0.6	0.8
24	1.1	2.1	0.6	1.7
25	0.5	0.3	0.4	0.1
26	1.4	1.7	1.5	0.1

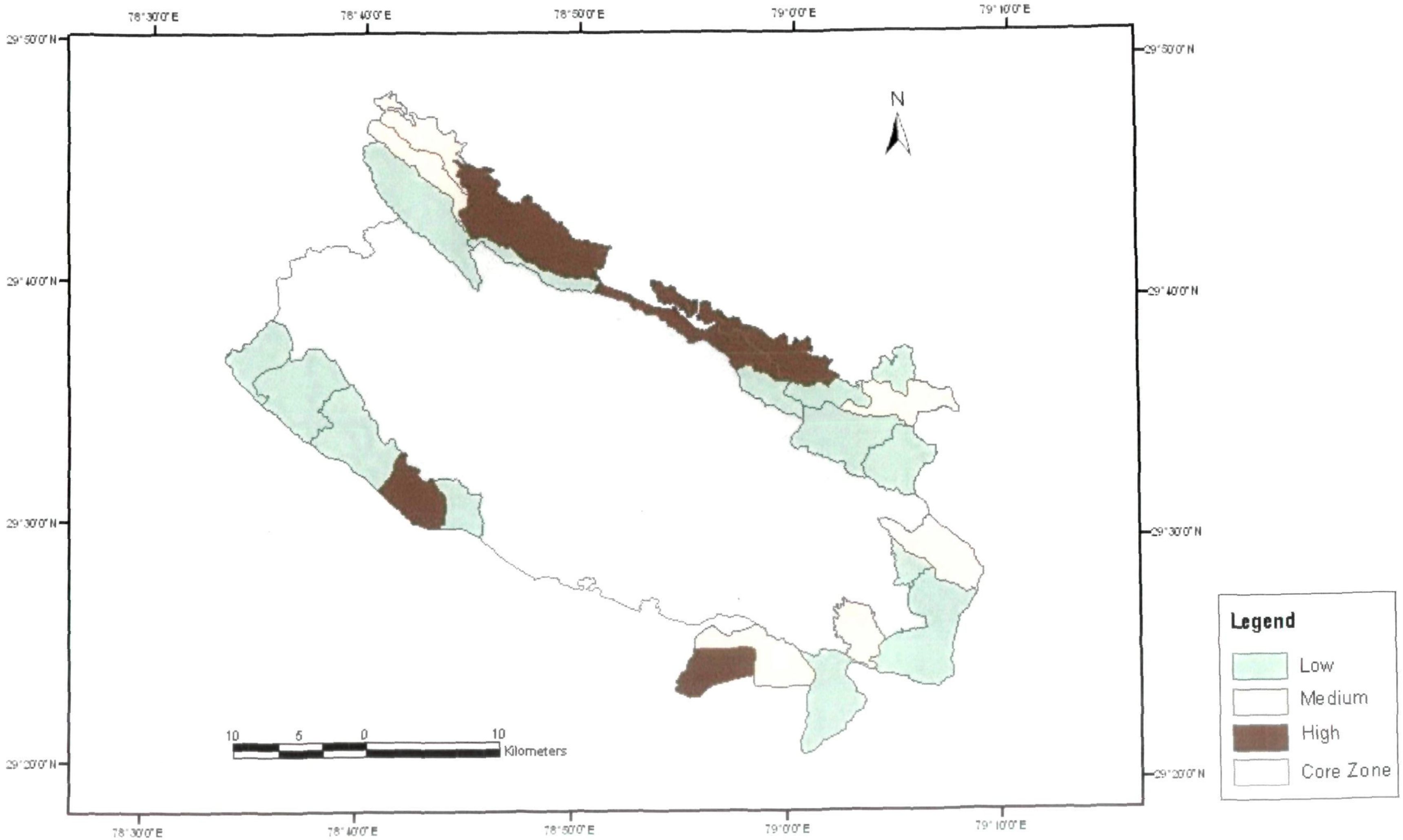
For block names see tabel 1.1, chapter I

The mean scores of different disturbance factors in sampled forest bocks were summarized (Table 7.16).The forest blocks of the BZ had significant ($P<0.01$, d.f. = 25) differences in terms of major disturbance factors, viz., cutting (K-W One Way ANOVA χ^2 = 271.45), lopping (K-W One Way ANOVA χ^2 = 262.8), dung pile density (K-W One Way ANOVA χ^2 = 312.85), abundance of shrub weeds other than *L. camara* (K-W One Way ANOVA χ^2 = 478.86), *L. camara* density (K-W One Way ANOVA χ^2 = 439.44) and percentage ground weed abundance (K-W One Way ANOVA χ^2 = 387.92).

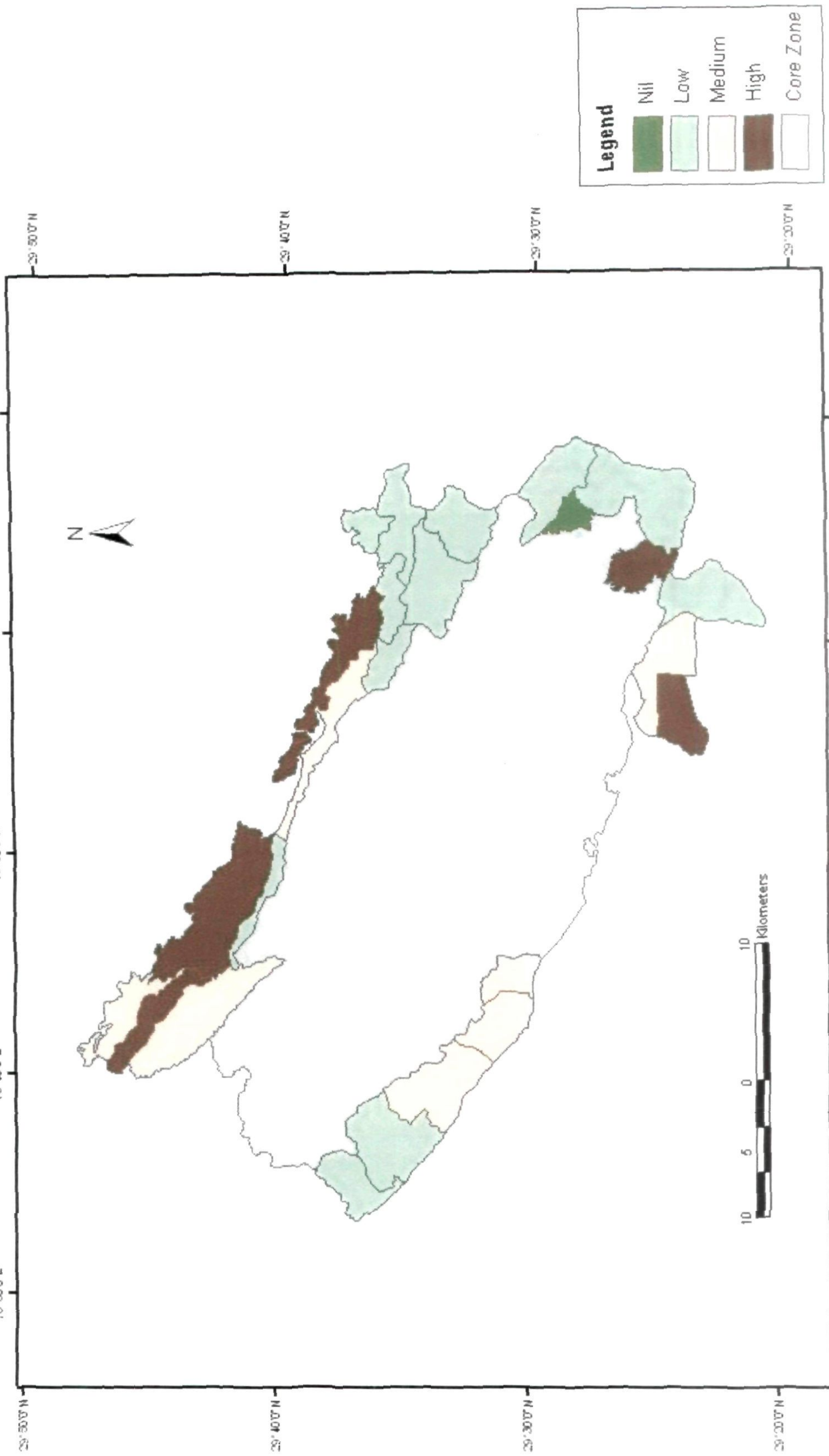
Cutting: Twenty three percent of the blocks of the buffer zone were under high intensity of cutting pressure. Most of these blocks were located in the northern portion of the buffer zone. Another 23% were under medium intensity of cutting pressure. These blocks were located in the north and eastern portion of the buffer zone. The remaining 54% of the blocks had low cutting pressure. These blocks were spread all over the buffer zone (Map 25 and Appendix IX).

Lopping: Twenty three percent blocks of the buffer zone had high degree of lopping pressure; most of these blocks were in the north of the buffer zone. Another 27% of the blocks were under medium lopping pressure. The rest of the blocks, except one block in the east, had low intensity lopping pressure. Most of the blocks with low intensity lopping pressure were located in the eastern portion of the buffer zone (Map 26 and Appendix IX).

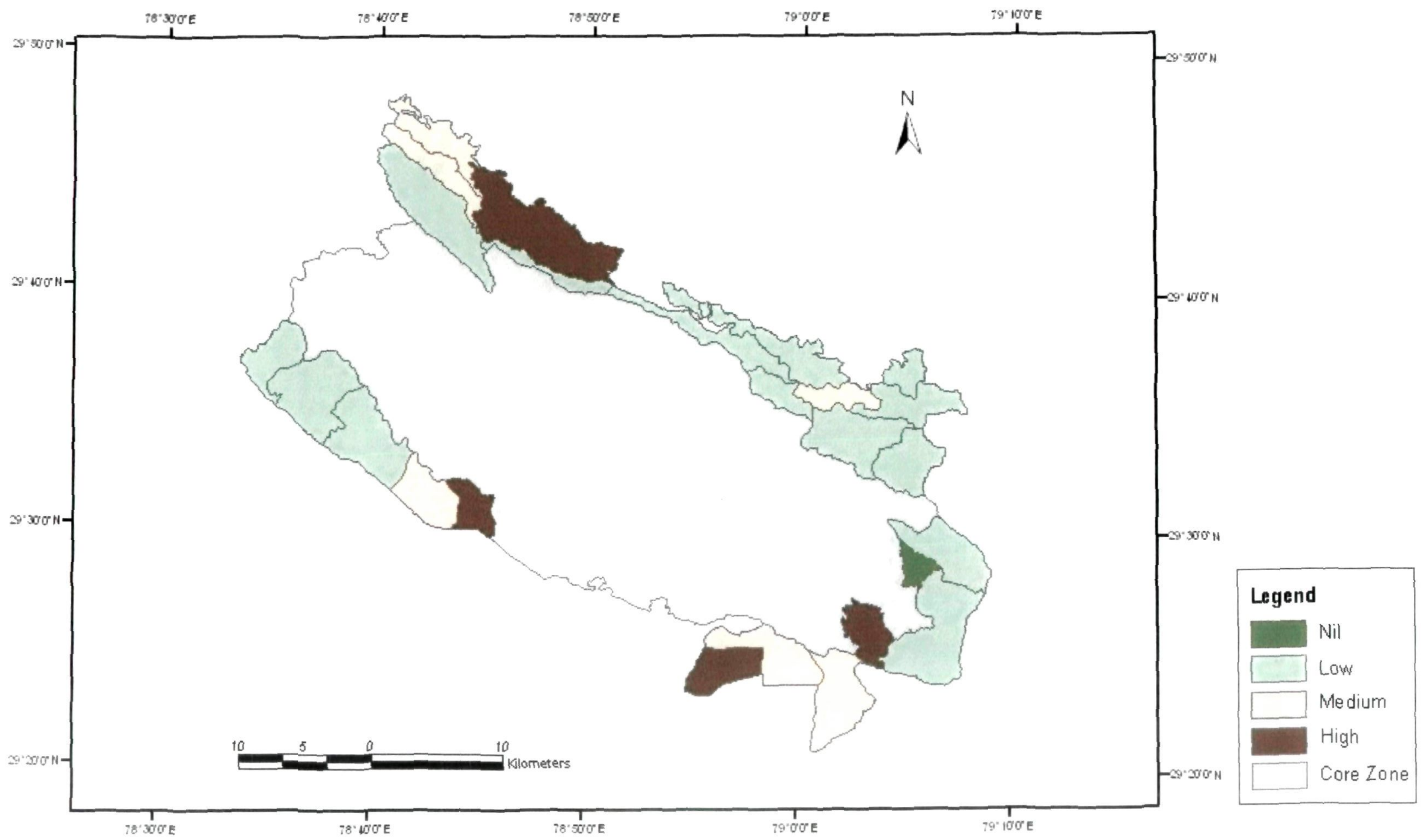
Grazing: Compared to cutting and lopping pressure, only 15% of the forest blocks were under high grazing pressure. While one of these blocks was located in the north, three were in the south of the buffer zone. Another 23% of the blocks were under medium grazing pressure; these blocks were located both in the north and the south of the buffer zone. Of the remaining blocks 62% blocks all except one were under low grazing pressure. Forest blocks with low grazing intensity were located all across the buffer zone, except in the south of the buffer zone (Map 27 and Appendix IX).



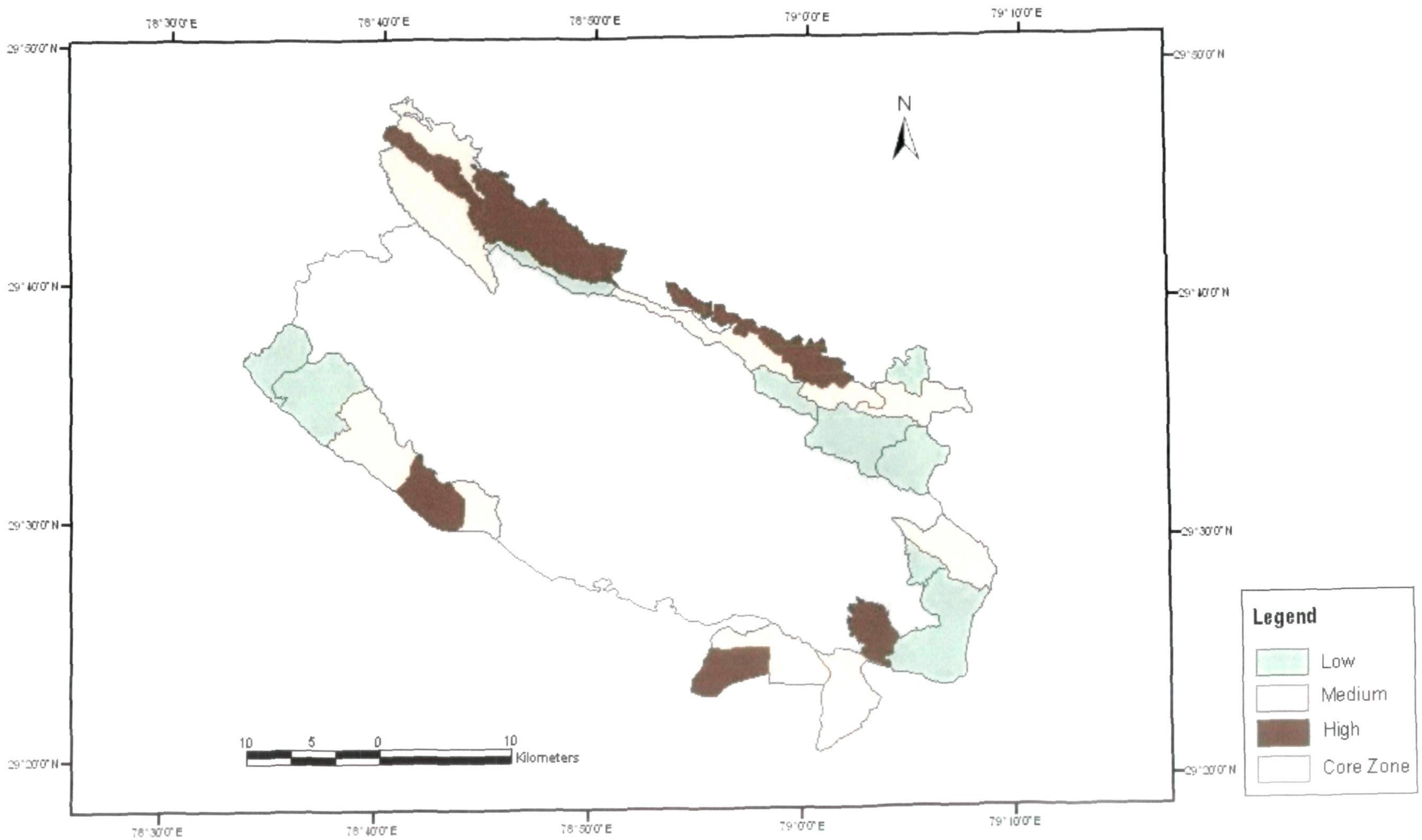
Map 25: Block-wise tree cutting pressure in buffer zone of the Corbett Tiger Reserve



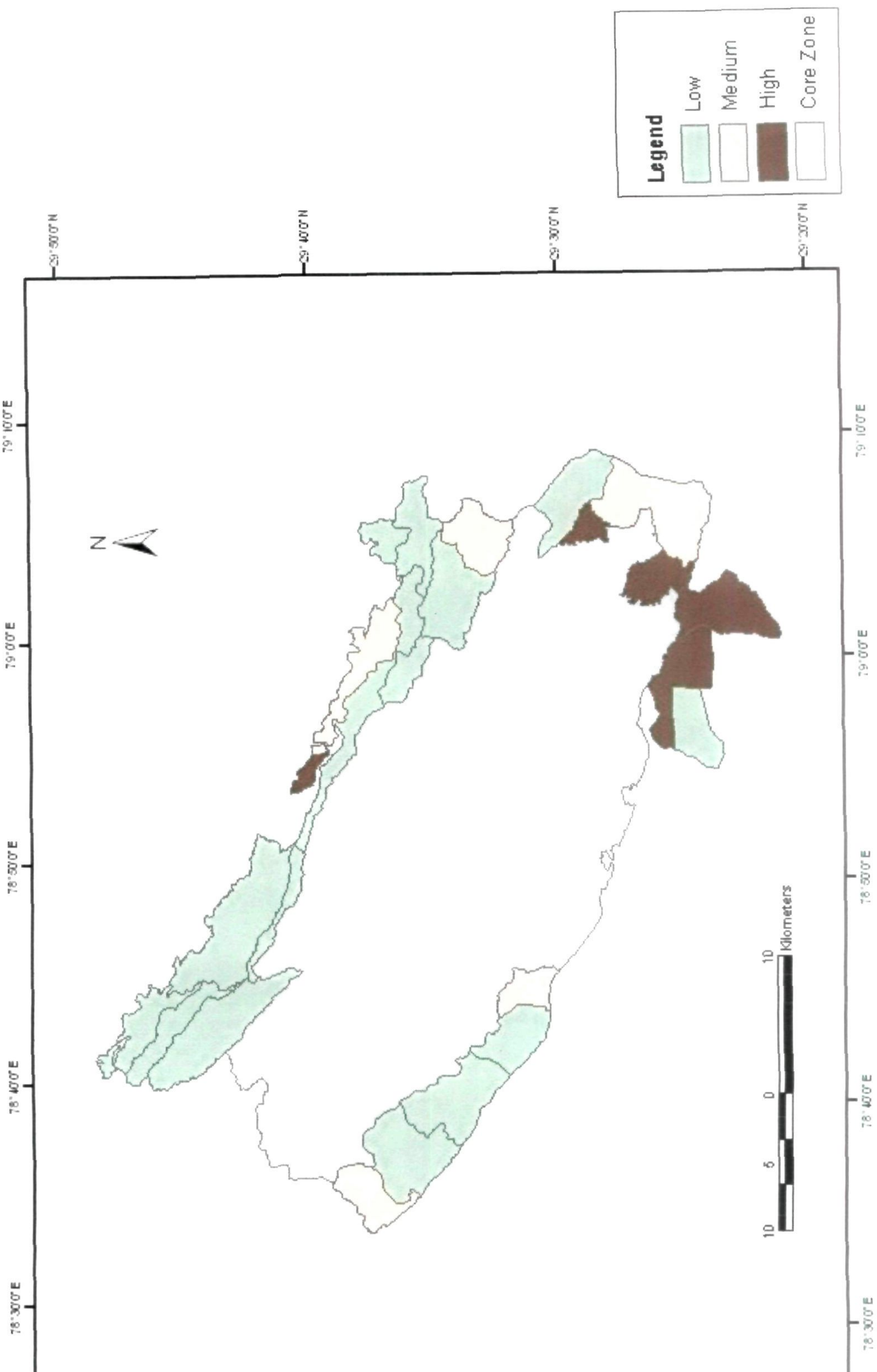
Map 26: Block-wise tree lopping pressure in buffer zone of the Corbett Tiger Reserve



Map 27: Block-wise grazing pressure in buffer zone of Corbett Tiger Reserve



Map 28: Block-wise biotic pressure in buffer zone of the Corbett Tiger Reserve



Map 29: Block-wise density of lantana in buffer zone of Corbett Tiger Reserve

Overall biotic pressure: The combined pressure from tree cutting, lopping and livestock grazing, was found to be high in 23% of the forest blocks of the buffer zone. These blocks were located both in the north and south of the buffer zone. Another 23% of the blocks were under medium intensity of biotic pressure, most of which were in the north. The rest of the blocks had low intensity of biotic pressure; most of these blocks were in the eastern portion of the buffer zone (Map 28 and Appendix XI).

Lantana abundance: While the majority of the forest blocks were under low density of *L. camara*, 19% of the blocks were under medium density and another 19% under high density of the weed. Most of the blocks with high density of the weed were located in the south-eastern portion of the buffer zone, while blocks with low density of *L. camara* were mostly located in the north and south-western portion of the buffer zone (Map 29 and Appendix IX).

Table 7.17: Block area under different disturbance factors in buffer zone of the Corbett Tiger Reserve (Hectares)

Disturbance factors	Nil	Low	Medium	High
Tree cutting	0	25703.9	9585.9	11468
Tree lopping	667.3	22047.6	13578.1	10464.8
Grazing (number	667.3	28869.6	9698.7	7522.2
Biotic pressure	0	15838.6	18802.5	12116.7
Lantana camara	0	30946.1	9227.9	6583.8

7.3.3. Prey abundance-habitat attributes relationship

The encounter rate of chital on different transects showed no significant correlation with any habitat attribute assessed on transects. The encounter rate of sambar was negatively correlated with grazing (r_s =-0.88, P<0.01), cutting (r_s = -0.67, P<0.05) and lopping (r_s =-0.68, P<0.05) only. The encounter rate of muntjac showed positive correlation with herb diversity (r_s

=0.79, P<0.01) and herb evenness (r_s = 0.71, P<0.05), grass richness (r_s = 0.78, P<0.01) and grass diversity (r_s = 0.94, P<0.01). The muntjac encounter rate was also significantly negatively correlated with grazing (r_s = -0.78, P<0.01), cutting (r_s = -0.84, P<0.1) and abundance of weed (r_s = -0.79, P<0.01). The encounter rate of wild pig did not show any significant correlation with any of the assessed habitat factors. The encounter rate of nilgai was found to be negatively correlated with tree richness (r_s = -0.70, P<0.05). It was also negatively correlated with herb richness (r_s = -0.73 P<0.05), herb diversity (r_s = -0.73, P<0.05), grass diversity (r_s = 0.73, P<0.05) and grass evenness (r_s = 0.73, P<0.05). The nilgai encounter rate was, however, positively correlated with grazing (r_s = 0.73, P<0.05). The pellet group density of chital in different forest blocks was positively correlated with cutting and weed abundance (r_s = 0.87 & 0.71, P<0.01 & 0.05). It was negatively correlated with grass richness and grass diversity (r_s = -0.78 & -0.70, P<0.05). The pellet group densities of sambar and muntjac did not show any correlation with various habitat factors including disturbance attributes. The wild pig dropping density was positively correlated with grazing (r_s = 0.80, P<0.01), livestock dung abundance (r_s = 0.74, P<0.05), cutting (r_s = 0.71, P<0.05) and weed abundance (r_s=0.86, P<0.01) and negatively correlated with herb diversity (r_s =-0.81, P<0.01), herb evenness (r_s = -0.76, P<0.01) and grass diversity (r_s = -0.66, P<0.05). The pellet group density of nilgai was negatively correlated with herb diversity (r_s = -0.69, P<0.05) and herb evenness (r_s = -0.84, P<0.01).

7.3.4. Habitat use by tiger

Table 7.18 provides details of the different habitat categories found in the intensive study area together with area under different habitat categories. Mixed, Sal, Sal mixed and Scrub makes up for a major portion (71.89%) of habitats types found in the intensive survey area during the second phase. During the study period, 624 direct and indirect sightings of tiger were recorded, of which maximum were recorded in the mixed vegetation whereas minimum number of sightings were recorded in the grassland habitat (Table 7.18).

Comparison of observed and expected frequency of occurrence of sightings in different habitats indicated significant difference between overall habitat availability and usage by tigers in the study area (χ^2 = 1111.7, d.f.= 7, p=0.01) and rejected the null hypothesis of random selection of habitat by tiger. Tigers in the study area used all the habitats in the survey area but showed strong preference for mixed vegetation (Table 7.19). Five habitat types Grassland, Plantation, Riverbed, Sal and Scrub were avoided whereas Riverine and Sal mixed were utilized in accordance to their availability in the study area by tigers (Table 7.19).

Table 7.18: Total number of evidence in different habitats together with total area of habitat in survey area

Habitat type	Total Area available (Ha)	Relative area (%)	Number of evidence
Grass land	11.48	06.1	8
Mixed	40.00	21.3	342
Plantation	21.56	11.5	48
Riverbed	05.79	03.1	9
Riverine	13.95	07.4	38
Sal	40.53	21.6	102
Sal mixed	25.79	13.7	67
Scrub	28.68	15.2	10

Table 7.19: Availability and expected proportional usage with 95% *bonferroni* confidence interval

Habitat type	Expected usage	Observed usage	Expected prop. Use (P_u)	Bonferroni intervals for P_i	Remark
Grass land	38.17	8	0.061	$0.001 \leq P_i \leq 0.025$	-
Mixed	132.99	342	0.213	$0.494 \leq P_i \leq 0.062$	+
Plantation	71.68	48	0.115	$0.048 \leq P_i \leq 0.106$	-
Riverbed	19.25	9	0.031	$0.001 \leq P_i \leq 0.027$	-
Riverine	46.38	38	0.074	$0.035 \leq P_i \leq 0.087$	**0**
Sal	134.75	102	0.216	$0.123 \leq P_i \leq 0.204$	-
Sal mixed	85.75	67	0.137	$0.074 \leq P_i \leq 0.141$	**0**
Scrub	95.02	10	0.152	$0.002 \leq P_i \leq 0.030$	-

-=Avoided, += Preffered, 0= used in accordance to availability

7.4. Conclusion and discussion

7.4.1 Habitat Conditions

The findings of the study pertain only to the buffer zone of the Corbett Tiger Reserve. Sal (IVI= 98.2) was found be the most dominant tree species whereas Rohini (IVI= 70.2) was co-dominant tree species in the buffer zone of the Corbett Tiger Reserve. The tree density (273.9 trees/ha) in the study area is quite below to tree density reported in tropical and temperate forest where it ranged 550 to 1800 trees/ha (Visalakshi 1995) and 320 to 2100 trees/ha (Dabel & Day 1977, Saxena & Singh 1982, Singh & Singh1984, Pandey & Singh 1985) respectively. The low tree density in the study area could be because of high biotic pressure of local people's anthropogenic activities since these activities have detrimental impact on vegetation.

North Jashpur forest block which had Sal and mixed vegetation type, had the highest tree density, and diversity of tree, the Dhela forest block with plantations and mixed habitat type had the lowest tree density as well as diversity. This (mixed and plantation) vegetation type also had the highest shrub density (Nalkatta forest block) as well as lowest shrub density (Dhela forest block). These findings indicated that rather than vegetation parameters there are some other factors which have impact on the on the shrub density and diversity. Dhela forest block, located in the southern portion of buffer zone, is under high anthropogenic pressure. Population of Dhela village, a large village (>2500 humans and livestock) located in the middle of the Dhela forest block, is totally dependent on forest to graze livestock and collection of grasses and leafy fodder. These anthropogenic activities of local people have negative impact on the recruitment of seedling and sapling and therefore there is decrease in the density and diversity of trees and shrubs. The areas under severe pressure of anthropogenic activities have low density of trees and shrubs. The study in Namdapha Tiger Reserve by Nath et al. (2005) also reported low density of shrub in disturbed areas in comparison of undisturbed areas. Regeneration of species is dependent on internal forest process and exotic disturbances (Barker & Kinkpatrick 1994). Loss of tree sapling as an effect of grazing has obvious effect for tree recruitment, and in long run affected structure and composition of forest (Madhusudan 2000). Nath et al. (2005) reported less recruitment of seedling to sapling in disturbed areas in comparison to undisturbed areas and this in long run decrease the density of trees in disturbed areas. The Nalkatta forest block, located in western part of study area, also makes the boundary of Uttar Pradesh and Uttarakhand state. After the creation of newly state Uttarakhand, the forest department restricted grazing and other activities in Corbett Tiger Reserve by the people living in Uttar Pradesh. In addition to this, there is no revenue village inside this forest block. Due to this, the forest block is under low pressure of anthropogenic activities and had maximum tree density and shrub density and diversity.

Tree diversity (0.5 to 1.0) is quite lower than the tropical forest where tree diversity is reported as 5.06 and 5.04 for young and old strand, respectively (Knight 1975). For Indian forests tree diversity is ranged from 0.83 to 4.1, as reported by several studies (Singh et al. 1984, Parthasarathy et al. 1992, Visalakshi 1995, Nath et al. 2005) and recorded tree diversity is within the reported range. On comparison of tree diversity with diversity value reported from the similar areas, it is found that it is quite close to outer Himalayas (0.53) but lower than shiwalik (1.84-2.44), Doon valley (1.39) and corridor between Corbett and Rajaji (3.58) as discussed by Rawat and Bhainsora (1999) and Aparajita De (2007). Moreover, Singh et al. (1995) recoded high tree diversity value (1.79-3.64) in Corbett National Park (core zone of the CTR). The low tree diversity in the study area might be because of high pressure of livestock grazing, collection of fuelwood and leafy fodder by local people which put negative impact on the survival of tree species. Tree species richness is decreased with increase in the intensity of disturbance (Nath et al. 2005). In addition to this, significant portion of buffer zone covered with plantations which are low in heterogeneity and contribute towards low diversity in the study area. More heterogeneity in natural forest than those of plantations cause for high diversity in natural forest (Pandey 1999). Tree richness and evenness were highest in Dumunda East, which also had a Sal and mixed vegetation type. This block had low grazing, cutting and lopping pressure. People depend on this block has alternative forest, in Ramanagar and Almora Forest Division, to graze their livestock and collection of fuelwood and fodder.

The tree density and diversity as well as shrub density in the different forest blocks were found to be significantly different. Since different forest blocks differ in vegetation composition, terrain, altitude and pressure of anthropogenic activities, therefore difference in density of trees and shrubs and diversity of trees among different forest block is understandable.

7.4.2 Impact of disturbance factors on habitat

The disturbance factors such as livestock grazing and collection of fuelwood and fodder have negative effect on the herb layer. Attributes of grass and herb layer showed negative significant impact of disturbance factors in terms of reduction in grass and herb diversity, richness and evenness. But Nath et al. (2005) reported more diversity and density of herbs in disturbed areas in comparison to undisturbed areas in Namdapha Tiger Reserve. This could be because, in the present study herbaceous weed species such as *Parthenium, Casia tora, Adhatoda vasica*, were not included to calculate attributes of herb layer. Herbaceous weed species were treated separately in the abundance of weeds. Disturbance factors promote spread of only herbaceous weed species. Impact of excessive grazing and removal of cattle dung from the forest was observed in the form of retarded species generation, frequent occurrence of exposed ground and preponderance of unpalatable herbaceous species and weed such as *Lantana camara* (Silori & Mishra 2001).

Grass density had showed positive correlation with grazing, cutting and weed abundance. The areas with high density of grass were used more to graze livestock by local people. Mostly people used to cut or collect fuelwood and leafy fodder to take away as head load at the time grazing of livestock and in result areas those used to graze livestock had high cutting pressure. Livestock grazing increases the proliferation of weed species and in turn areas with high pressure of livestock grazing have high density of weed species. Moreover, areas with high density of grass over used by local to graze livestock and had high weed abundance and cutting pressure, but under the pressure of grazing, grass diversity is decreased. Findings of the study indicated the same pattern and therefore grass diversity was negatively correlated with grazing and cutting pressure.

Study has shown that cutting and lopping pressure was more intensive in northern portion in comparison of rest part of study area. This could be because local people living in northern part of the study area were totally depend on the forest for their resource needs, whereas people living in others parts, to some extent have agriculture land to grow fodder for their livestock. Moreover people living in northern part have marginal agriculture land in which they are not able to grow fodder for their livestock. In addition to this, mostly there is no irrigation facility in northern portion and agricultural practice is totally dependent on rain which reduces production. Due to this, agricultural land is not sufficient to grow fodder for their livestock. Therefore people living in northern part were more involve in extraction of leafy fodder for their livestock in comparison of people living in other parts. But in contrast to cutting and lopping pressure, grazing was found more intense in southern portion because human settlements in southern part area are more populated in comparison of northern portion and had high population of livestock which put more intense grazing pressure on the forest area in this portion.

7.4.3 Prey abundance-habitat attributes relationship

The findings suggested that chital, nilgai and wild pig also utilized areas with moderate to high levels of disturbance whereas sambar and muntjac show clear avoidance for disturbed areas. Chital and nilgai preferred the areas with flat terrain and same areas were preferred by local people to graze livestock and collection of fuelwood and fodder. Moreover, chital gathered in night close to human settlement to avoid predator. Wild pig attached themselves close to human settlement since they raid crops of local people during night. Therefore chital, nilgai and wild pig adapt to tolerate moderate to high level of disturbance. Sambar shows its preference for hilly terrain, dense cover and absence of biotic pressure (Johnsingh 1983, Khan et al. 1990). Similarly, Indian muntjac, solitary ruminant, inhabits dense cover (Sheng 1992) and come out in open areas very seldom (Barrette 1977). Moreover, for muntjac selection of high cover could be anti-predator strategy (Teng et al. 2004). Ungulate calves select high percentage of cover as a strategy to defend against predators (Gerlach & Vaughan 1991, Bowyer et al. 1998, Bowyer et al. 1999). Since, areas having high disturbance are degraded and have low cover therefore, they are avoided by sambar and muntjac.

7.4.4 Habitat use by tiger

Result of habitat use indicated that tigers are distributed throughout the study area and used all the available habitats but tigers were found to exercise some choice in selection of different habitats. Tigers were found to be preferring mixed vegetation and avoided grassland, plantation, riverbed and pure Sal habitats. Mixed vegetation has sufficient under story cover which helps tiger in ambushing the prey. Moreover mixed vegetation is more diverse in nature and has more grasses and palatable shrub species and is used more by herbivores as habitat provides sufficient forage to wild herbivores and in turn due high availability of herbivores, utilized more by tiger. The distribution of tiger is governed by distribution and abundance of herbivore prey species (Karanth & Sunquist 1995, Miquelle et al. 1996 and Karanth & Nichols 1998) and prey density and distribution, not habitat parameters, are the key factors driving first and second order selection of habitat by tigers and other factors are important at third order (Miquelle et al. 1999). Therefore mixed habitat, rich in herbivores abundance, was used more than its availability by tiger in the study area. Bhat & Rawat (1995) reported selection of mixed vegetation by chital, principal prey species of tiger, in Rajaji National Park. In addition to this, local people preferred to graze livestock in mixed vegetation in comparison of other habitats. More availability of livestock, which contributed significant portion of tiger's diet in buffer zone, could also be a factor behind preference of mixed vegetation by tiger. The finding was also supported by fact that maximum numbers of livestock kills were recorded in the mixed vegetation (Chapter 5). Generally it is considered that grassland habitat is preferred by tiger since it has potential to support high biomass of herbivores. In contrast to this, situation in present study is totally different and grassland habitat was found to be used less than its availability. This could be because; study was conducted in the buffer zone which is subjected to high anthropogenic pressure of local people. Grassland habitat in buffer zone is intensively used by local people to graze their livestock and collection of grasses. During day time grasslands are occupied by local people. Tiger is shy animal and generally avoid human contact. Therefore under these circumstances tiger used less grassland habitat in comparison to its availability in study area.

Plantation and pure Sal habitats are low in diversity and density of grass and palatable shrub species and this result in low abundance of herbivores. Therefore plantation and pure Sal were utilized less than their availability. Riverbeds are dry rivers courses with no vegetation cover and in absence of vegetation cover; these areas were not suitable for tiger since tiger needs cover to ambush prey species. Suitable cover is essential for solitary nocturnal carnivores like tiger and majority of kills found in areas with dense vegetation (Sunquist 1981). Importance of cover characteristics in selection of habitat types for stalking and feeding has been emphasized for cougar by several studies (Laing 1988, Koehler & Hornocker 1991 and Williams et al. 1995). Similarly, for tigers in study area, mixed vegetation provide necessary stalking and feeding cover for tiger as maximum number of kills were recorded in mixed vegetation. Rest of the habitats as Sal mixed, riverine and scrub were found to be used in accordance to its availability. But tigers in Russian Far East were reported to strongly prefer riverine habitat (Miquelle et al. 1999). Riverine habitats in the study area are occurring in small patches and poor representations of riverine habitat on vegetation map have skewed result and due to overestimate of riverine vegetation, it was used in proportion to its availability.

8.1 Introduction

The forests in most of the developing countries are under pressure due to diversion of forest to non-forestry uses (Lal 1989), as well as, exploitation for meeting the subsistence needs of the rapidly growing population, majority of which lives in extreme poverty (Guha 1994). The problem of local communities' dependence on Protected Areas (PAs) is much more complex than it appears to be. At times the sectoral programs of other agencies in the region are also counter-productive to the objectives of conservation. However, the problem is not confined to PAs only in India.

Moreover, with the depletion of resources outside the PAs, the pressure on the PAs and wildlife has further increased. Consequently, most of the PAs in India are facing problems related to human-wildlife conflict which has arisen due to lack of compatibility between conservation interests of protected areas and needs and aspirations of local people in and around the protected areas. This is the outcome of major lacunae in planning a PA, i.e., overlooking human needs and aspirations of the local population and the lack of and/or inadequacy of mechanism to deal with ensuing conflicts (Durbin & Ralambo 1994). Moreover, in most cases PA-people relationship which are also of paramount importance in resolving conflict between PAs and local people communities (Lusigi 1981, Abel & Blaike 1986, Carew-Ried 1990, Tablot & Olindo 1990) are also not given due consideration. However, over the past several years, the approach towards resolving PA - people conflicts has undergone a major change. It has been realized that it is not possible to protect our forests and wildlife by mere policing. What is needed is an approach which would address the ground realities of poverty, lack of alternatives, especially for fuel and fodder, the impact of wildlife on local people, due to shrinking forests and depleting prey base and local people's attitudes towards forests and conservation. Studies carried out in different parts of the world have also concluded that socio-economic characteristics of the region determine the type and intensity of threats to the PAs (Hart 1966, Nelson 1978, Blower 1984).

There is need for understanding the external factors affecting PAs, so that its management would be tailored to effectively address the adjacent land and local people's issues. The management therefore cannot be indifferent to the resource needs and perceptions of local people (Schelhas 1991, Rodgers 1991). The scale and magnitude of the wildlife-human conflict however, varies between different PAs. In some of the PAs the problem of wildlife-human conflict has been reported to be severe. Therefore, there is a need to carry out case-specific studies for identifying the factors responsible for these conflicts. Unfortunately, there is a general lack of quantitative and objective assessment of the nature of tiger-human conflict across tiger range and there is even greater lack of understanding of factor responsible for occurrence of conflict on spatial and temporal scale.

The situation in the Corbett Tiger Reserve (CTR) is not very different from that being faced by other tiger reserves across India. There are 123 villages and 17 *Gujjar deras* (settlements) in and around the BZ (Map 30). While 36 of these villages and *deras* are located within buffer zone (BZ) of the Corbett Tiger Reserve, Goujada, a *Gujjar dera,* is located within Core Zone of the CTR. The villages located within and around the buffer zone are dependent in some way or the other on the resources of the CTR. Three of the villages located as intrusions on the southern boundary of the CTR (Dhara, Jhirna and Kothirau) were relocated in 1994 and another peripheral village (Laldhang) located in Nainital district is in final stage of implementation (Bhartari 1999).

While people's dependence on the PA has an impact on the forest and wildlife of the area, due to their proximity to the Corbett Tiger Reserve, the local people are also affected by cattle lifting and crop raiding by wild animals.

Socio-economic survey of the villages and *Gujjar deras* located in and around the buffer zone was conducted, to assess people's dependence on the buffer zone. Moreover, local people's attitudes to restrictions on resource-use and conservation and their implications for the management *vis-a-vis* tiger human conflict issue were also assessed.

8.2 Methodology

Data on various socio-economic parameters and people's dependence on the forest were collected through both primary and secondary sources. Secondary data on the villages and *Gujjar deras* in the buffer zone were collected from the Forest Department, National Information Centres (NIC's) and *Gram sabhas (*village councils). A reconnaissance survey was carried out in all of the 123 villages and 17 *Gujjar deras* in buffer zone of the Corbett Tiger Reserve (Map 30). A questionnaire was used to collect basic village level information on the communities residing, human and livestock populations, occupational and agricultural patterns, basic facilities and problems, dependence on the forest for livestock grazing, fuel wood and non-timber forest products (NTFP) and the forest blocks used. Nature of human-wildlife conflict and people's attitudes to alternatives to forest resources was also assessed using questionnaires (Appendix X).

Degree of human and livestock dependence on the forest blocks and dependence for fuelwood, and grass fodder on the forest blocks of the buffer zone was assessed on an ordinal scale of 0-3 where 0 represented lack of dependence for either of resource and 3 represented highest degree of dependence (Table 8.1). The human and livestock population dependent on the forest blocks was calculated on the basis of the data collected in the socio-economic survey of the villages. However, degree of dependence on the buffer zone for fuelwood and fodder was quantified on the basis of direct observation of the groups of livestock entering and number of people leaving with head loads of fuelwood and grass fodder. These scores were then mapped to see the spatial distribution of biotic dependence on buffer zone of the Corbett Tiger reserve.

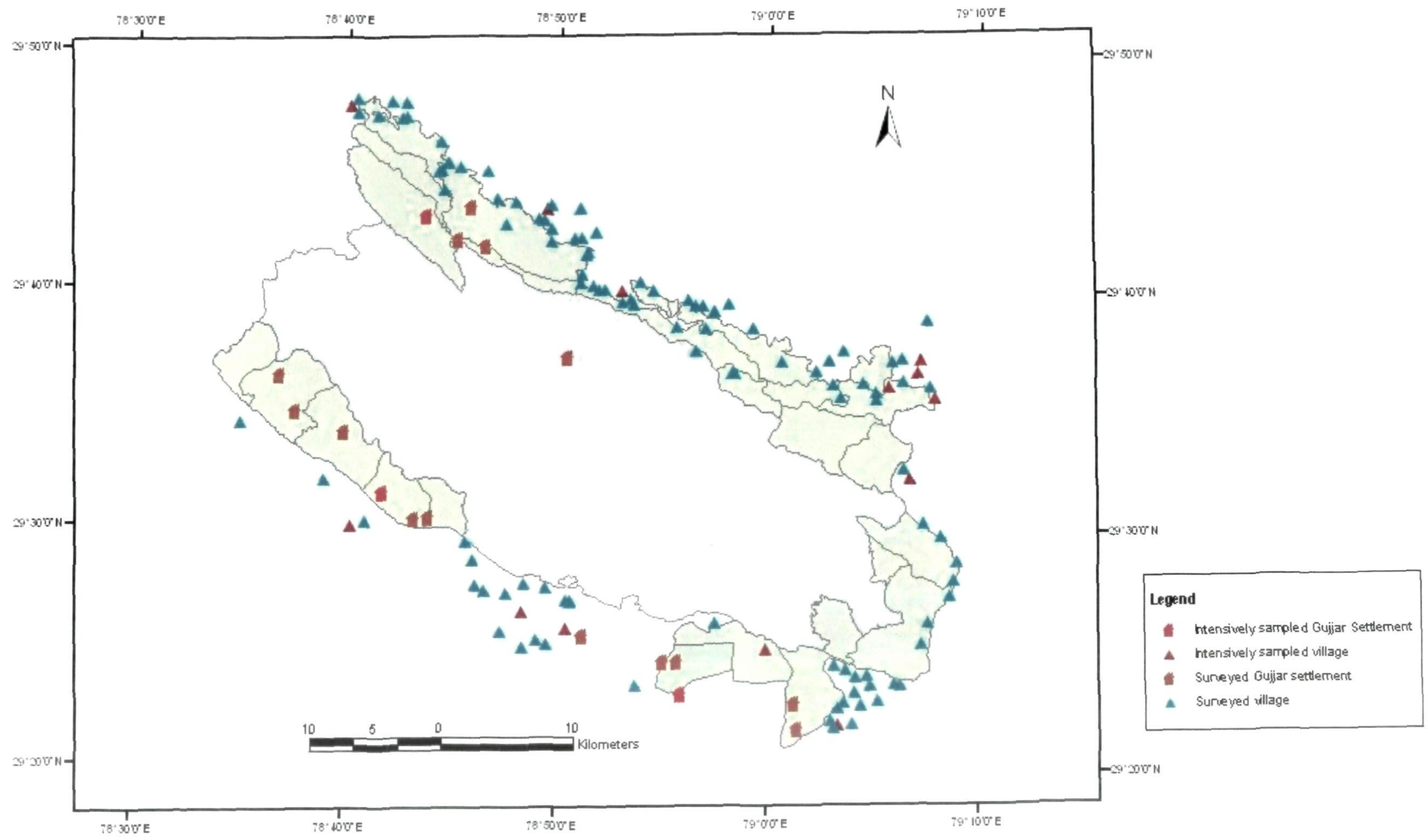
The reconnaissance survey was followed by a more detailed survey in the sample villages and *deras* (Map 30). For selecting sample villages, the buffer zone was divided into four zones, viz., I (Northwest), II (Northeast), III (Southeast) and IV (Southwest). This was done to ensure selection of villages and *deras* from the entire buffer zone. A total of 13 villages and 3 *deras* were selected for intensive sampling, on the basis of human and livestock populations as well as their spatial location *vis-a-vis* the buffer zone. Questionnaires were used to collect detailed information on socio-economic and demographic profile of communities in the sample villages and *deras* as well as, people's attitudes towards resource use, alternatives for reducing dependence on resources of the buffer zone, and conservation of CTR and wildlife (Appendices XI, XII, and XIII).

Table 8.1: Scores assigned for assessment of degree of biotic dependence on the buffer zone of the Corbett Tiger Reserve

Degree of dependence	**Low**	**Medium**	**High**
Human* (persons / Ha)	0.01-0.5	0.6-1	>1
Livestock* (per Ha)	0.01-0.5	0.6-1	>1
Fuelwood (headloads extracted from CTR / day)**	1-10	10-20	>20
Grass fodder (headloads extracted from CTR / day)**	1-10	10-20	>20

**Based on the socio-economic survey of the villages.*

*** Based on direct observation of groups of livestock entering the BZ and people leaving the BZ with headloads of fuelwood and grass fodder.*



Map 30: Location of villages and Gujjar settlements in and around buffer zone of the CTR

The data collection process had however, some limitations. Due to shortage of time and logistic limitations data collection could not be intensive. Therefore the study is based on the information provided by the local people as no intensive monitoring of resource extraction could be carried out. Moreover, community based group responses were recorded in the sample villages, rather than carrying out a door-to-door survey since it is a more time consuming process. As some of the peripheral villages were located in the state of Uttar Pradesh, detailed secondary information on these villages could not be gathered, due to non-cooperation by the NIC office.

8.3 Results

8.3.1 Spatial distribution of dependent villages

Although there were no villages inside the core zone of CTR, a Gujjar *dera* (Goujada) was located inside the core zone. While 21 villages and 15 *deras* were located within the buffer zone, 29 villages and 2 *deras* were located adjacent (within 1 km) to the boundary of the buffer zone. The remaining 73 settlements (villages and *deras*) were located within a distance of 1-7 km of the buffer boundary (Map 30, Appendices XIV and XV).

There were a total of 59 villages and *deras* in Zone I, out of which 17 were located within the buffer zone. The remaining 42 villages and *deras* were located either adjacent to the boundary of the buffer zone or outside the boundary within a distance of 3 km. Zone II had 23 dependent villages, out of which 5 were located inside the buffer zone. Of the remaining 18 peripheral villages, 4 were adjacent to the buffer zone while 14 were located within a distance of 4 km of the buffer zone boundary. There were however, no Gujjar *deras* in this zone. Zone III had 25 dependent villages and 2 *deras,* out of which 6 were located inside the buffer zone. Of the remaining 21 villages, 12 were adjacent to the buffer zone boundary while 9 were located within a distance of 5 km of the boundary. In Zone IV there were 21 dependent villages and 10 *deras*. In this zone there were no villages inside the buffer zone, however, there were 8 *deras* located within the buffer zone. While 9 villages and 2 *deras* were adjacent to the buffer zone boundary, 12 villages were located within 7 km of the buffer zone (Table 8.2).

Table 8.2: Spatial distribution of dependent villages and *deras* in around the buffer zone of the Corbett Tiger Reserve

Location of villages and deras viz. a viz. BZ	Zone I	Zone II	Zone III	Zone IV	Total
Total villages	54	23	25	21	123
Number of villages inside BZ	12	5	4	0	21
Number of villages adjacent to BZ boundary	4	4	12	9	29
Number of villages within a distance of 7 km from BZ boundary	38	14	9	12	73
Total Gujjar *deras*	5	0	2	10	17
Number of *deras* inside BZ	5	0	2	8	15
Number of *deras* adjacent to BZ boundary	0	0	0	2	2

BZ = Buffer Zone of Corbett Tiger Reserve.

8.3.2 Broad profile of dependent villages and *Gujjar deras*

Human and livestock populations: The human population was a heterogeneous group of 15 communities living across 140 villages and *deras* in and around the buffer zone (Table 8.3). While overall there were a total of 77803 people and 58534 heads of livestock dependent on the resources of the buffer zone, Zone II had the smallest human (7873) and livestock (6629) populations. On the other hand Zone IV had the largest human (35496) and livestock (21644) populations. Zone I, despite the highest number of villages and *deras* (59) however, had a lower human population than both Zones III and IV, although its livestock population was larger than that of Zone III (Table 8.4). The 17 Gujjar *deras* accounted for almost 800 people and more than 2000 heads of livestock of the total human and livestock population on the study area (Table 8.5).

Table 8.3: Communities living in around the buffer zone of the Corbett Tiger Reserve

Zone I	Zone II	Zone III	Zone IV
Brahmin	Brahmin	Brahmin	Buxa
Gujjar	Harijan	Gujjar	Christian
Harijan	Rajput	Harijan	Gadhwali
Rajput		Jatsikh	Goudhya
		Muslim	Gujjar
		Raisikh	Jatsikh
		Rajput	Kamboj
			Kumarsikh
			Odd Rajput
			Raisikh
			Saini

Table 8.4: Zone-wise human and livestock populations of the villages and *deras* in and around the buffer zone of the Corbett Tiger Reserve

Zone	I	II	III	IV	Total
Number of villages and *deras*	59	23	27	31	140
Number of communities	4	3	7	11	15
Human population	15271	7873	19163	35496	77803
Livestock population	18578	6629	11683	21644	58534

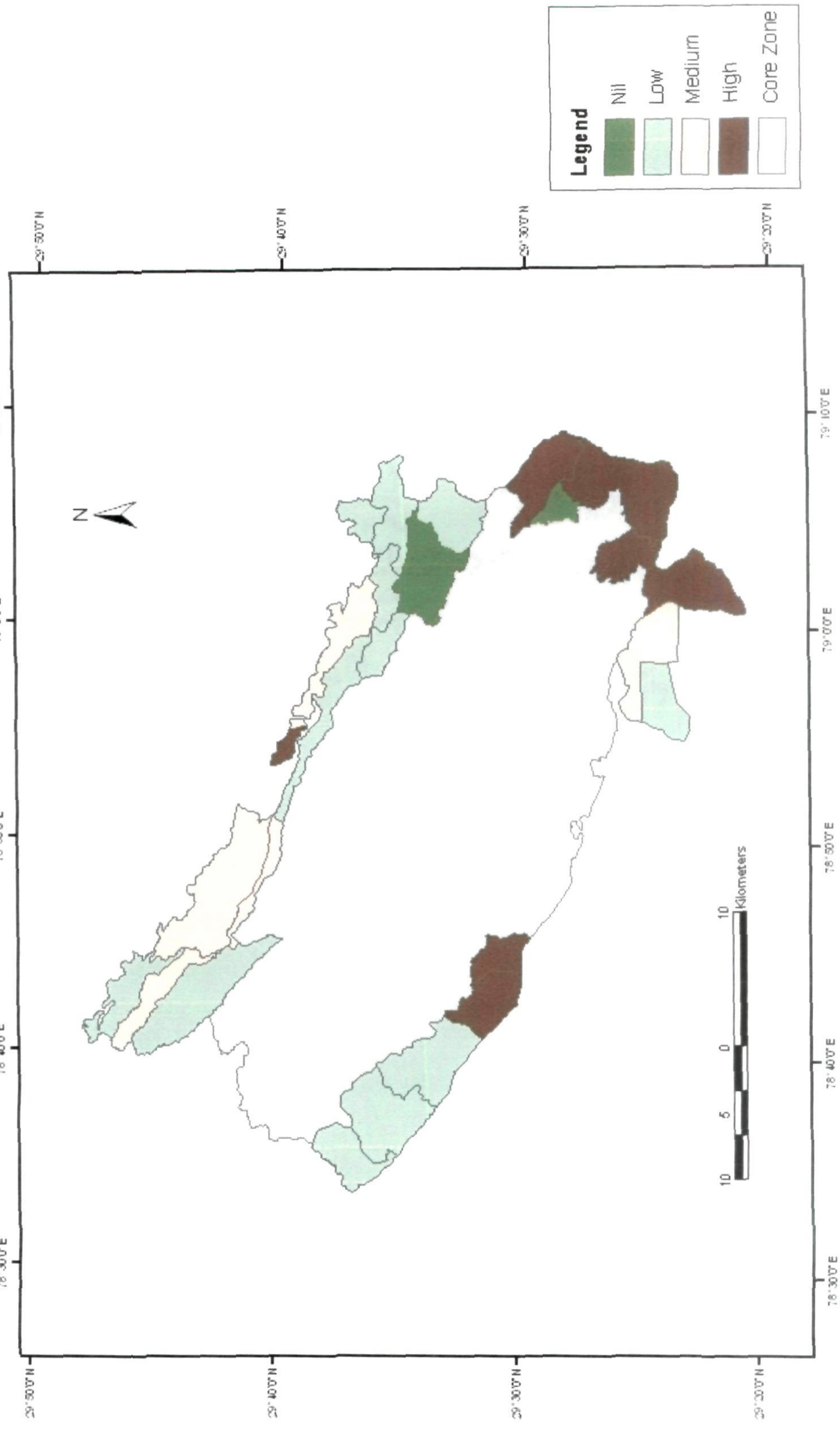
Table 8.5: Average family size and livestock per family in villages and *Gujjar deras* in and around the buffer zone of the Corbett Tiger Reserve

Parameters	Village	*Gujjar dera*
Average family size	7.1	5.8
Livestock per family	5.1	20.4

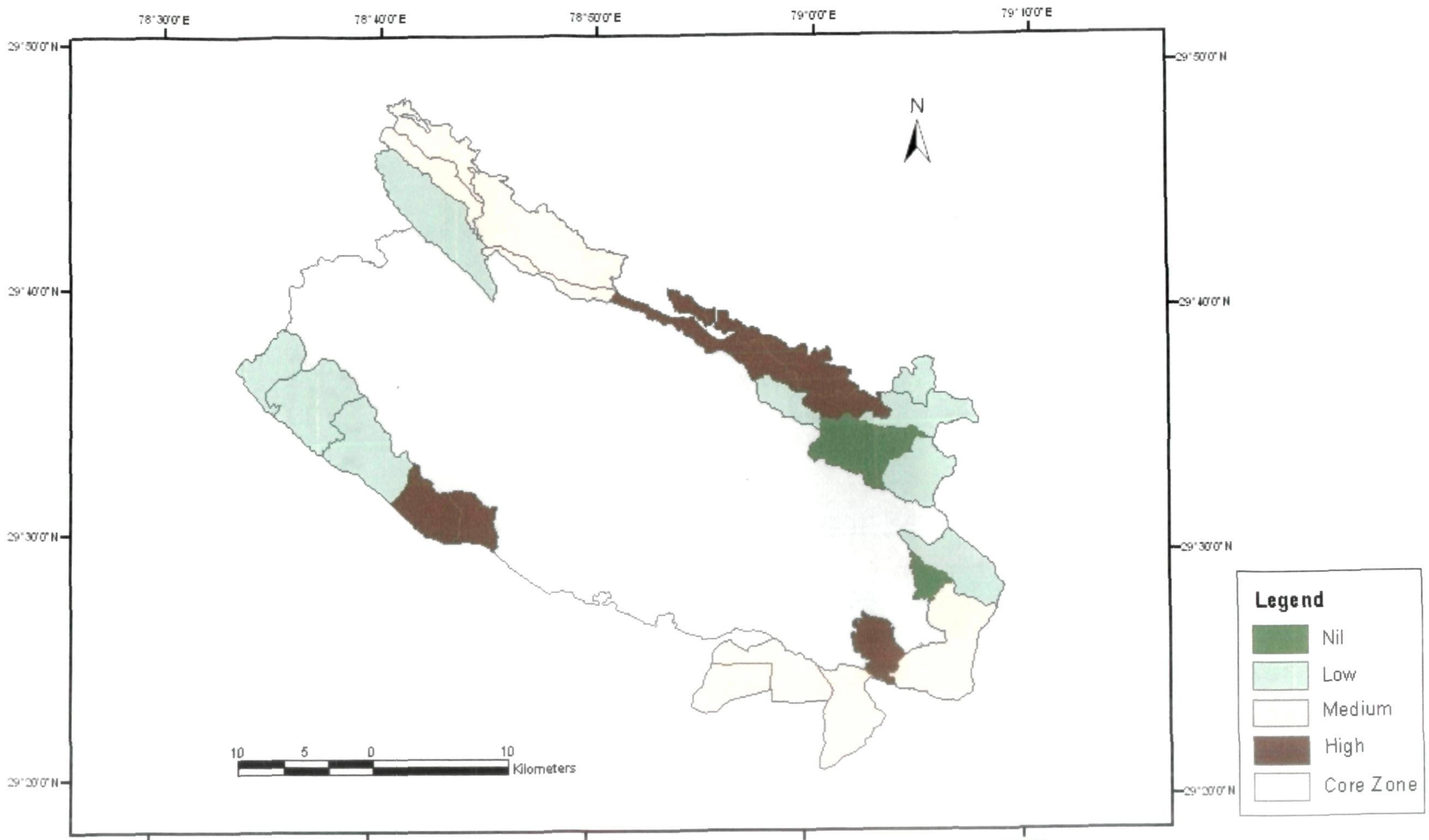
Zone-wise details of the deras given in Appendix 15

Block-wise distribution of human population showed that out of the 26 forest blocks in the buffer zone, 7 of the forest blocks (26.9%) were under high degree of human dependence, while 5 (19.2%) had medium degree of human dependence. Out of the remaining blocks, 12 (46.1%) were under low degree of human dependence, and 2 (7.6%) were free of human dependence (Appendix XVI). Spatially, all except 2 of the blocks under high human dependence were mostly located in the southeast portion of the buffer zone. Most of the blocks under medium degree of human dependence were however, located in the northern portion of the buffer zone with only one of the blocks being in the southeast. Most of the blocks in the northeast and southwest of the buffer zone were under low degree of human dependence. The two blocks, which were free of human dependence, were located in the east of the buffer zone (Map 31).

As far as block-wise dependence of livestock population was concerned, the pattern was more or less similar to human dependence, with 7 (26.9%) of the forest blocks under high degree of dependence, and 2 of the blocks free of livestock dependence. The number of blocks under medium degree of livestock dependence was however higher (8 blocks i.e., 30.7%) compared to those under human dependence. On the other hand, the number of blocks under low degree of livestock dependence was comparatively less (9 blocks i.e., 34.6%) to those under human dependence (Appendix XVI).



Map 31: Human population dependent on forest blocks of buffer zone of the CTR



Map 32: Livestock population dependent on forest blocks of buffer zone of the CTR

Spatially, most of the blocks under high degree of livestock dependence were located in the north region of the buffer zone, with only 2 of the blocks in the southern region. Blocks under medium degree of livestock dependence were located mostly in the northwest and southeast of the buffer zone. On the other hand, blocks under low dependence were mostly clustered in the northeast and southwest. The two blocks free of livestock dependence were the same as those free of human dependence and located in the eastern portion of the buffer zone (Map 32).

Livestock holding pattern: While the Gujjars had more than 30 animals per household, the Odd Rajputs had more than 10 animals per household. Out of the remaining 13 communities, 5 had an average livestock holding of 6 to 9 animals per household, while 8 of the communities had 5 or less animals per household (Fig. 8.2).

Resource dependence pattern: In Zone I, less than 75% of the villages and *deras* depended on the buffer zone for grazing their livestock. However, all the villages and *deras* in this zone were dependent on the buffer zone for fuelwood and grass. While in Zone II, while less than 75% of the villages depended for grazing their livestock in the buffer zone, all the villages depended on the buffer zone for fuelwood and grass requirements. While less than 50% of the villages in this zone depended on the buffer zone for timber, less than 25% were dependent for food. None of the villages in Zone II depended for medicines on the buffer zone (Table 8.7).

In Zone III, more than 75% of the villages and *deras* depended on the buffer zone forest for grazing their livestock and their requirements for fuelwood and grass. While less than 50% of the villages and *deras* were dependent for timber on the buffer zone, less than 25% were dependent for food and medicine on the forest (Table 8.7).

Table 8.6: Crops, vegetables and fruits grown by the local people in and around the buffer zone of the Corbett Tiger Reserve

Season	Cash Crop	Non-Commercial crop
Winter	Wheat (*Triticum aestivum*)	Barley (*Hordeum vulgare*)
	Sugarcane (*Saccharum officinarum*)	Masoor (*Lens esculentum*)
		Udad (*Phaseolus mungo*)
	Mustard (*Brassica compestris*)	Moong (*Phaseolus aureus*)
	Onion (*Allium cepa*)	Gram (*Cicer arietinum*)
	Ginger (*Zingiber officinale*)	Potato (*Solanum tubersum*)
		Pea (*Pisum sativum*)
		Turmeric (*Crucuma domestica*)
		Rai (*Brassica juneca*)
		Banana (*Musa paradisiaea*)
Summer	Groundnut (*Arachis hypogea*)	Mandua (*Eleusine coracana*)
	Ginger (*Zingiber officinale*)	Jhungara*
	Red Chilli (*Capsicum annum*)	Gahat*
	Soyabean (*Glycine max*)	Maize (*Zea mays*)
	Til (*Sesamum indicum*)	Rice (*Oryza sativa*)
	Peppermint (*Mentha piperata*)	Udad (*Phaseolus mungo*)
	Mango (*Mangifera indica*)	Chulai (*Amaranthus caudatus*)
	Lechee (*Litehi chinensis*)	Turmeric(*Crucuma domestica*)
		Kudo*
		Sava*
		Onion (*Allium cepa*)
		Masoor (*Lens esculentum*)
		Jowar (*Sorghum vulgare*)
		Bajra (*Pennisetum typhoides*)

**Local indigenous varieties of cereals; scientific names of these varieties could not be identified.*

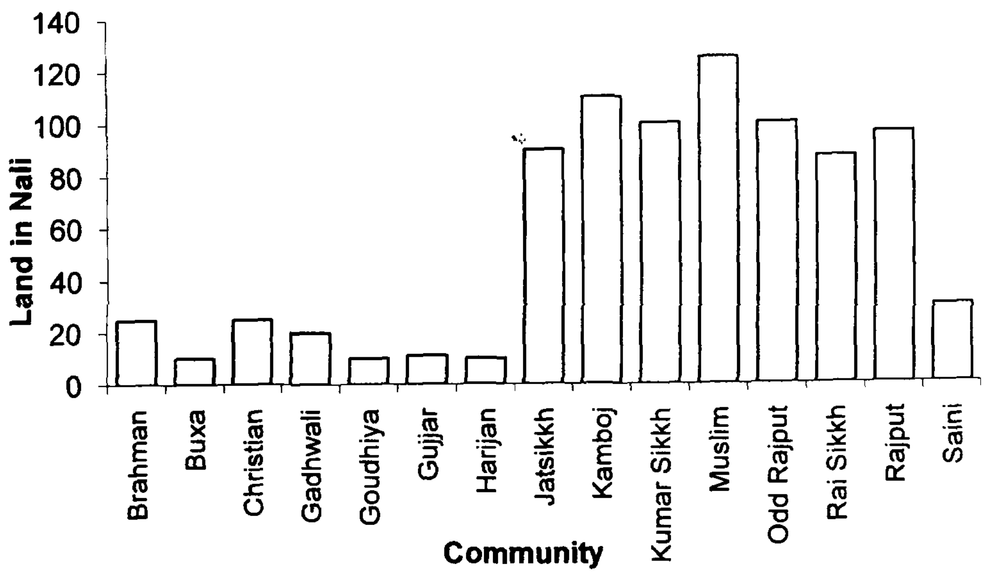


Figure 8.1: Average landholding/household in different communities in the buffer zone of the CTR

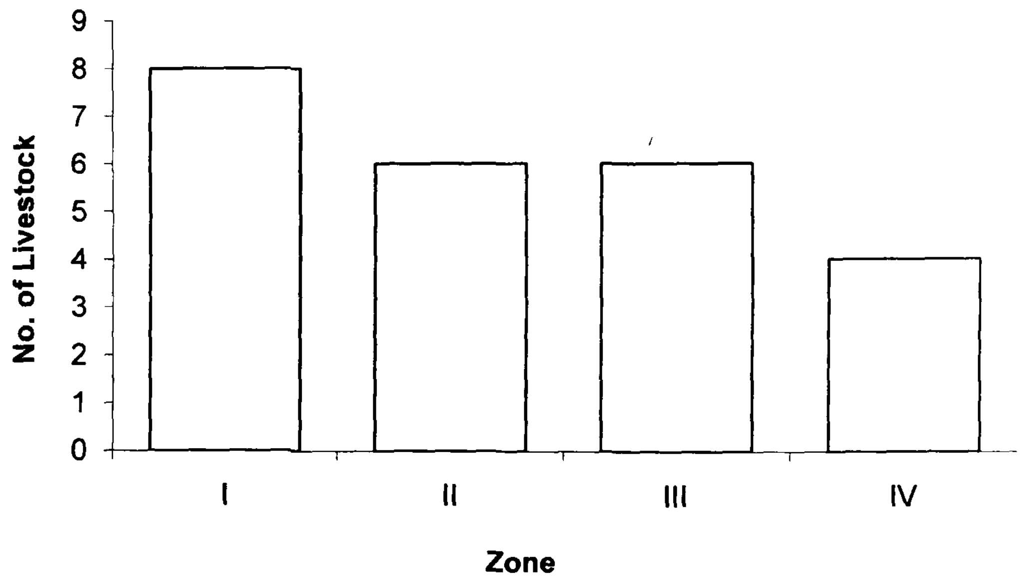


Figure 8.2: Average Cattle holding/household in different zones in and around buffer zone of the CTR

Table 8.7: Resource dependence on the buffer zone of the Corbett Tiger Reserve (percentage of villages and *deras*)

Resources	Zone I	Zone II	Zone III	Zone IV
Grazing	71.19	60.87	77.78	48.39
Fuelwood	100	100	96.29	96.77
Grass	100	100	92.59	80.64
Timber	22.03	43.48	48.15	54.84
Food	25.42	4.35	11.11	25.81
Medicine	1.69	-	3.7	-

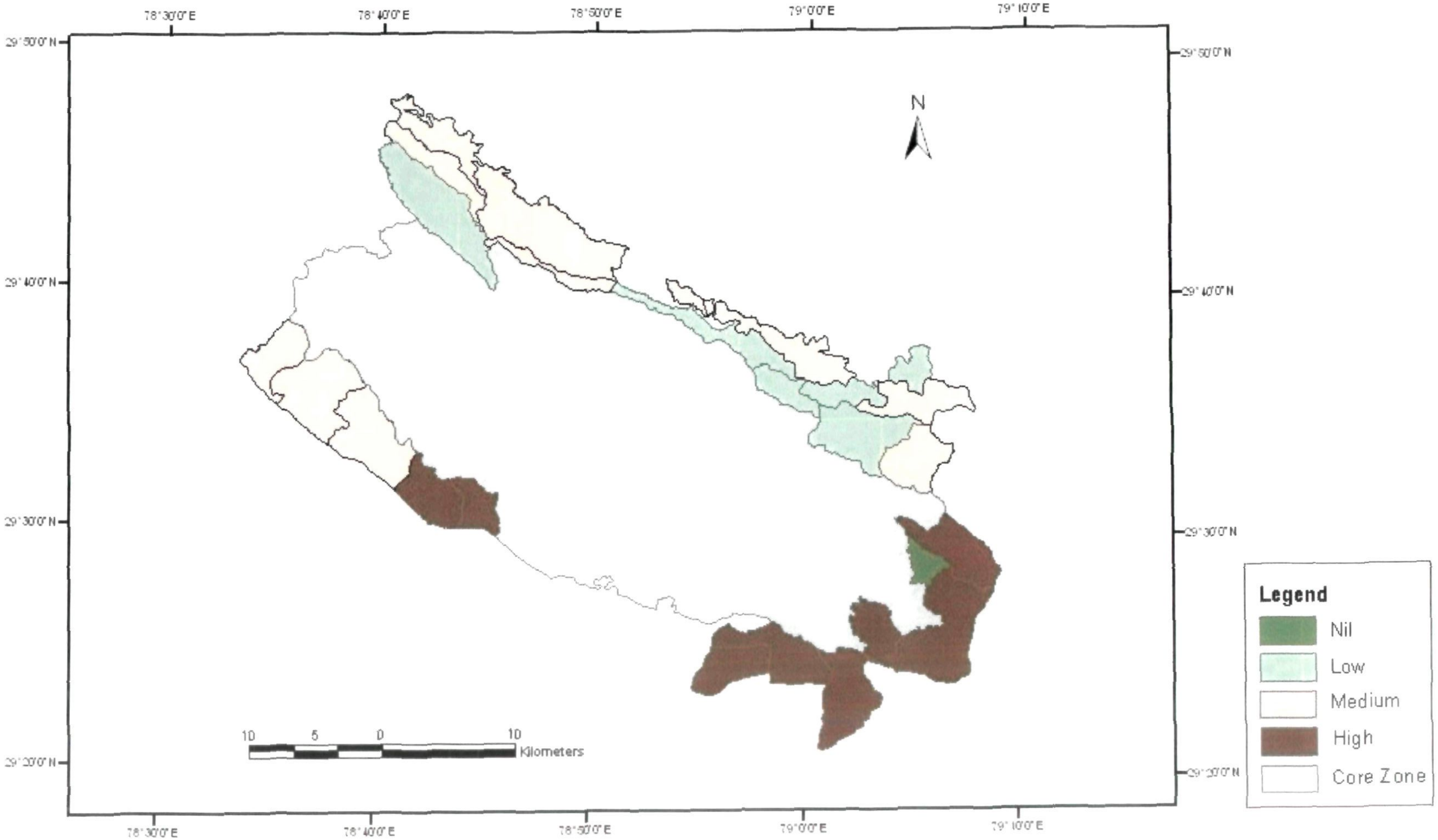
Note: The percentages will not add up to '100' as each village could be dependent on more than one resource.

Finally in Zone IV, less than 50% of the villages and *deras* were dependent on the buffer zone for grazing their livestock. However, more than 75% of the villages and *deras* in this zone depended on the buffer zone for meeting their fuelwood and grass requirement. While more than 50% of the Zone IV villages and *deras* were dependent for timber from the buffer zone, 25% of the villages and *deras* depended for their food from the forest. None of the villages and *deras* however, reported dependence on medicinal plants from the forest (Table 8.7).

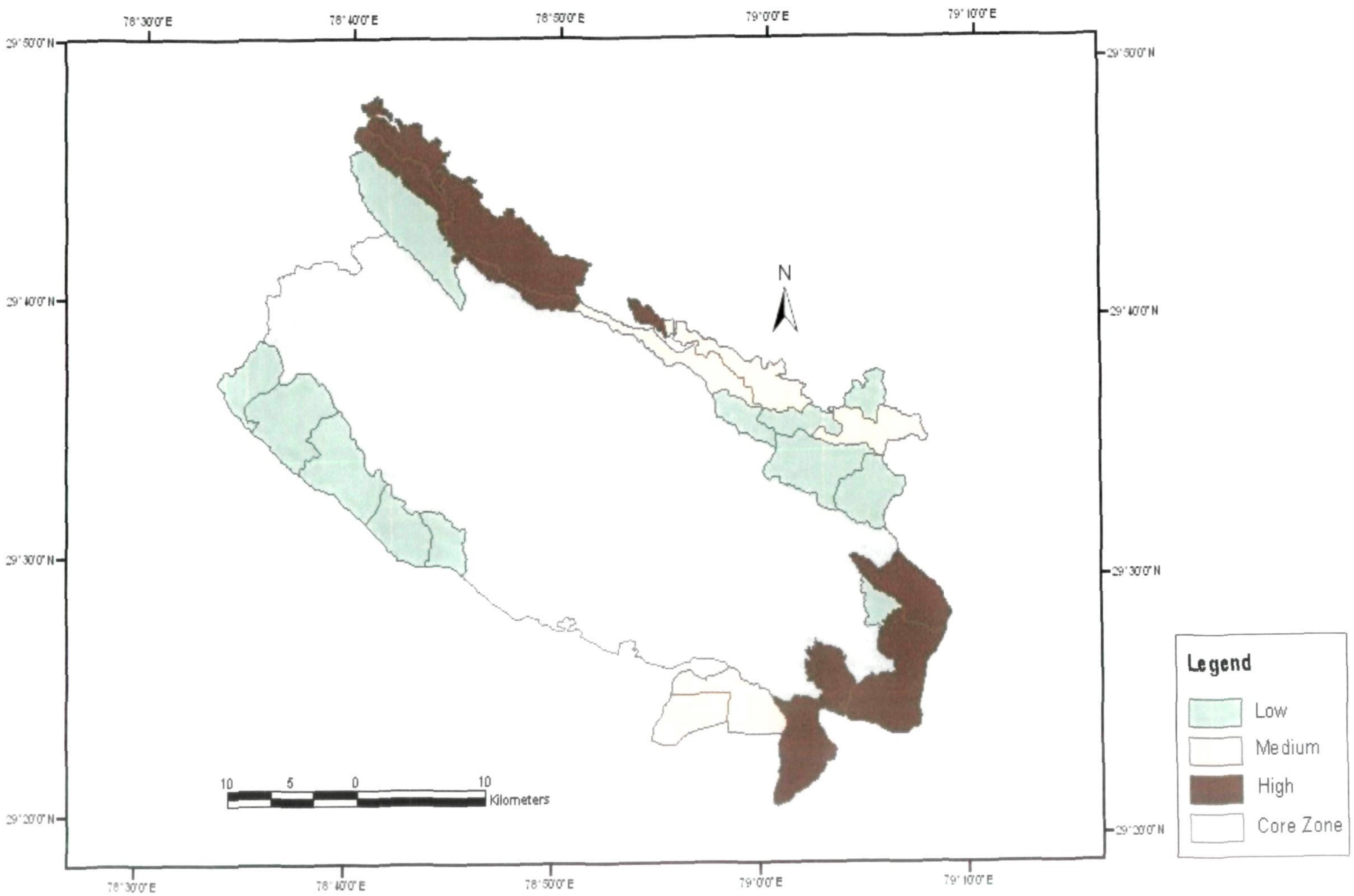
Block-wise dependence for fuelwood and grass fodder was mapped (Maps 33 and 34) and the respective areas under each resource use were calculated (Appendix XVI). As far as block-wise dependence for fuelwood was concerned, 30.7% (8) of the forest blocks were under high degree of dependence, while 42.3% (11) of the blocks were under medium degree of dependence. Of the remaining 7 blocks, 6 (23% of the total forest blocks) were under low dependence for fuelwood, while only 1 was free of dependence for fuelwood (Map 33, Appendix XVI). Spatially, the blocks under high degree of dependence for fuelwood were located in the south of the buffer zone, while blocks under medium dependence were spread across the buffer zone except in the southeast of the buffer zone. The blocks under low dependence were located only in the north of the buffer zone with one block, which was free of dependence for fuelwood located in the southeast (Map 33).

Dependence for grass fodder was high in 9 (34.6%) of the forest blocks. While 5 (19.2%) of the blocks were under medium degree of dependence for grass fodder, 12 (46.1%) were under low dependence. However, none of the forest blocks were free of dependence for grass fodder (Appendix XVI). Spatially, forest blocks under high degree of dependence for grass fodder were clustered either in the northwest or in the southeast. Blocks under medium degree of dependence for grass fodder were mostly located in the eastern portion of the buffer zone. While all the blocks in the southwest of the buffer zone were under low degree of dependence for grass fodder, most of the blocks in the northeast and one each in the northwest and southeast were in this category. None of the blocks were however, free of dependence for grass fodder (Map 34).

Status of forest: A zone-wise analysis of forest blocks used for grazing purposes showed that while 10 forest blocks were used in Zone I, five each were used in Zones II and III, and 6 forest blocks were used in Zone IV (Table 8.8). Although in Zone I, the buffer zone area under biotic use was the highest (164.654 km^2), the visual status of the forest was found to be 'good' in this zone. In comparison the status of the forest in the other three zones viz., II, III and IV was 'average', despite comparatively smaller areas of the buffer forest being used by the people and their livestock in these zones (Table 8.8).



Map 33: Dependence for fuelwood on forest blocks of buffer zone of the CTR



Map 34: Dependence for grass fodder on forest blocks of buffer zone of the CTR

Table 8.8: Forest blocks used for livestock grazing, area used and status of forest in the buffer zone of the Corbett Tiger Reserve

Parameters	Zone I	Zone II	Zone III	Zone IV
Forest blocks used	Adnala, Mandal, Bijoragadh, Kugadda, Kartia, East Mandal, Haldgaddi, Lohachaur, Khansur, Goujada	Dumunda(E), Dumunda(W), Jameria(W), Kalakhand, Era	Dhela-Bhabar, Sawaldeh-Bhabar, Sawaldeh-Hill, Phooltal, Dhulwa (E)	Kalagadh, Nalkatta, Pakhrau, Dhaulkhand, Kalushahid, North Jashpur
Total number of blocks used	10	5	5	6
Forest area used (km^2)	164.654	73.766	123.357	105.601
Forest status	Good	Average	Average	Average

Basic amenities: As far as the basic amenities of health, education, transport and markets were concerned, 22% of the villages and *deras* in Zone III had health facilities, while none of the villages and *deras* in Zone IV had locally available health facilities. 10% of the villages and *deras* in Zone I and only 4% in Zone II had basic health facilities (Table 8.9).

In comparison, facility for basic primary education was available in more than 45% of the villages and *deras* across the four zones. More than 74% of the villages and *deras* in Zones I and III and 45% to 56% of the villages and *deras* in Zones IV and II had facilities for primary education (Table 8.9).

Table 8.9: Availability of basic amenities in the villages in and around buffer zone of the Corbett Tiger Reserve (percentage of villages)

Basic needs	Zone I	Zone II	Zone III	Zone IV
Health	10.17	4.35	22.22	-
Education	77.97	56.52	74.07	45.16
Transport	43.37	34.78	73.91	25.81
Markets	-	3.45	18.52	32.26

Note: The percentages will not add up to '100' as each village could be dependent on more than one resource.

As far as transport facilities were concerned, highest number of habitations (villages and *deras*) in Zone III had access to transport (73%). Only 25% of the habitations in Zone IV had access to transport, whereas more than 34% of habitations in Zones I and II had transport facilities (Table 8.9).

The availability of market facilities to the people was very poor. While none of the Zone I habitations had access to local markets, only 3% of Zone II habitations had access to markets. However, comparatively 18% to 32% of the habitations in Zones III and IV respectively had access to local markets (Table 8.9).

Problems: There were certain problems which not only hampered day to day life in the villages but also adversely affected quality of life of the villagers (Table 8.10). Ten major problems were identified. While in Zone I lack of electricity was identified as a major problem in more than half of the villages and *deras* (65.52%), lack of- medical, communication, irrigation and drinking water facilities were considered as a problem in less than 50% of the villages and *deras*. Flood related problems (viz., breakdown of communication and soil erosion), lack of – education facilities, employment opportunities, village pastures and weed infestation were considered a problem by people in less than 25% of the habitations (Table 8.10).

In Zone II, people in more than half of the habitations (69%) considered lack of irrigation facilities as a problem. Lack of – electricity, medical, communication and drinking water facilities were a problem for less than 50% of the habitations and flood related problems in monsoons and lack of education facilities were reported by less than 25% of the villages and *deras*. None of the villages however, had problems with lack of employment opportunities and village pastures or weeds infestation (Table 8.10).

In Zone III, local people in more than 50% of the habitations considered lack of medical facilities as a major problem, while less than 50% considered inadequate supply of drinking water and absence of village pastures as a major problem. Absence of village pastures results in higher dependence on the buffer zone forest for grazing of livestock. This results in livestock predation by wild animals, especially the tiger. People in less than 25% of the villages and *deras* however, considered lack of electricity, communication (roads and bridges), irrigation and education facilities, as well as flood related problems and lack of employment opportunities as major problems. Weed infestation was not a problem in any of the villages in this zone (Table 8.10).

In Zone IV, people in more than 50% of the villages and *deras* considered lack of-medical, communication (roads and bridges) and drinking water facilities as major problems. In less than 50% of the habitations lack of irrigation and education facilities and absence of village pastures were considered as major problems. Lack of electricity, flood related problems of breakdown of communication and soil erosion were considered as major problems in less than 25% of the villages and *deras*. However, none of the villages or *deras* in this zone had either the problem of lack of employment opportunities or weed infestation (Table 8.10).

Table 8.10: Problems in the villages and *deras* in and around the buffer zone of Corbett Tiger Reserve (percentage of villages)

Problems / Zones	I	II	III	IV
Lack of electricity	65.52	30.43	11.11	19.35
Lack of medical facilities	42.37	34.78	59.26	58.06
Lack of communication facilities- roads and bridges	40.68	43.48	11.11	51.61
Lack of irrigation facility	40.68	69.57	22.22	38.71
Lack of drinking water	33.89	26.09	37.04	58.61
Flood related problems- break down of communication and soil	11.86	8.69	11.11	3.23
Lack of education facilities	13.56	8.69	18.51	48.39
Lack of employment opportunities	10.17	-	7.41	-
Weed infestation	1.69	-	-	-
Absence of grazing area or pastures within the villages	5.09	-	40.7	29

Note: The percentages will not add up to '100' as each village could be dependent on more than one resource.

Table 8.11: Wildlife related problems in the villages and *deras* in and around the buffer zone of Corbett Tiger Reserve (percentage of villages)

Wildlife related problems	Zone I	Zone II	Zone III	Zone IV
Threat to livestock	*100*	*100*	*81.5*	*96.8*
Threat to human life	-	-	-	12.9
Crop depredation	98	100	81	87

Note: The percentages will not add up to '100' as each village could be dependent on more than one resource.

Wildlife related problems: Three major wildlife related problems emerged in the study area, viz., (1)crop depredation by wild ungulates, (2) threat to human life by wild animals and (3) threat to livestock by wild animals. Threat to livestock and crop depredation emerged as two major wildlife-related problems as local people in more than 80% of the villages and *deras* in each of the four zones were affected by these problems. While none of the people in villages and *deras* of Zones I, II and III considered wild animals as a threat to human life, local people of less than 25% of the villages in Zone IV considered this as a problem (Table 8.11).

8.3.3 Village profile of sample villages and Gujjar *deras*

Four habitations (villages and *deras*) were sampled in each of the zones. While the human population was most heterogeneous in Zone IV, with 12 communities, Zone II had only 3 communities residing in the sample villages. Data were collected from 2023 households across 16 sample villages and *deras*. Zone IV had the highest number of sample households (1205) and highest sample population (8266). Zone I had the lowest number of sample households (205) and also the lowest sample population (1286). The sample villages in zone II were also much less populated (1813) compared to zones III and IV (Table 8.12).

Out of the total 2023 households sampled across the four zones in and around the buffer zone, 12.46% (252) of the households belonged to the landless. While average landholding size per household showed an increasing trend as we moved from zone I to IV, average livestock holding per household showed a decreasing trend from zone I to IV. However, the total livestock in sample villages and *deras* was highest in zone IV (4820) and lowest in Zone II (Table 8.12).

Table 8.12: Broad profile of sample villages and *deras* in and around buffer zone of the Corbett Tiger Reserve

Parameters	Zone I	Zone II	Zone III	Zone
Number of villages and *deras*	4	4	4	4
Number of communities	4	3	7	12
Number of households	205	268	345	1205
Human population	1286	1813	2531	8266
Average land holding/household *(nali)*	15	31	36	69
Total livestock	1640	1508	2070	4820
Average livestock holding/ household	8	6	6	4

50 Nali = 1 Hectare.

The 3 Gujjar *deras* which were included in the sample were Khansur (Zone I), Phanto (Zone III), and Nemsot (Zone IV). Two of these *deras*, namely Phanto and Nemsot were mixed *deras*, which also included the '*Khattas*' (land alloted by the Government to the local people inside the forest). Except for Khansur, which had only Gujjar households, Phanto and Nemsot also had other communities (Brahman and Goudhiya) residing in them. Out of the three *deras* Khansur had the lowest number of households (8) as well as total human population (43) and average household size (5). On the other hand, Nemsot had the highest number of households (13), with a total human population of 135 (Goudhiyas = 100 and Gujjars = 35). The average household size in Nemsot was also highest compared to other *deras*, viz., 9 for Goudhiyas and 17 for the Gujjars (Table 8.13).

As far as the livestock population of these *deras* was concerned, Phanto in Zone III had the largest livestock population (532), followed by Khansur in Zone I (121), while Nemsot in Zone IV had comparatively the lowest livestock population (117). Average livestock holding per household was also highest in Phanto (Brahmins = 140 cattle / household and Gujjars = 65 cattle / household). The Goudhiyas in Nemsot however, had the lowest average livestock holding (4) per household (Table 8.13). As far as landholding is concerned, none of the communities, except the Goudhiyas in Nemsot had small patches of land on which they practiced subsistence agriculture.

Table 8.13: Broad profile of sampled *deras* in and around buffer zone of the Corbett Tiger Reserve

Zone	Name of the dera	Communities	Number of households (Average household size)	Human population	Total livestock	Average livestock holding/ household
I	Khansur	Gujjar	8 (5)	43	121	15
III	Phanto	Brahmin	1 (6)	6	140	140
		Gujjar	6 (7)	45	392	65
IV	Nemsot	Goudhiya	11 (9)	100	44	4
		Gujjar	2 (17)	35	73	36
Total	3	3	28	229	770	-

Demographic profile of sample villages and deras: Overall the sample villages and *deras* had 15 communities residing in them. While 8 of the communities had a human population of less than 500 individuals, the remaining 7 communities had a human population of more than 500 individuals. While the Christians had the lowest population with only 5 individuals, the Raisikh community had the highest population with more than 3000 individuals in the sample villages across the four zones. The number of children across the communities also showed a similar trend (Table 8.14).

Table 8.14: Community-wise demographic profile of sampled households in and around buffer zone of the Corbett Tiger Reserve

Community	Human population	Male	Female	Children
Brahmin	2098	632	675	791
Buxa	600	180	170	150
Christian	5	2	1	2
Gadhwali	1500	450	550	500
Goudhiya	100	35	25	40
Gujjar	165	44	42	79
Harijan	854	250	232	372
Jatsikh	167	66	59	42
Kamboj	1975	600	485	890
Kumarsikh	200	65	35	100
Muslim	106	35	29	53
Odd Rajput	80	19	16	45
Raisikh	3425	945	964	1504
Rajput	2366	751	771	844
Saini	255	77	57	121
Total	13896	4151	4111	5533

Occupational pattern: Five occupation types were identified for the sample villages in the study area viz., 1) agriculture, 2) business, 3) cattle rearing, 4) labour activities, and 5) service. While 12 of the 15 communities practiced agriculture as the major occupation, the remaining 3 communities practiced it as a secondary occupation (Table 8.15). Cattle rearing and labour activities were the other two major occupations practiced by three communities each. While only one of these communities viz., Gujjars, had only cattle rearing as their major occupation. The third major occupation was service, practiced by 2 of the 15 communities.

Labor was a subsidiary occupation for 10 out of 15 communities. Service was a subsidiary occupation for 6 of the communities. These communities had agriculture as their primary occupation. Three of the communities had agriculture as their subsidiary occupation. Cattle rearing was also the secondary or subsidiary occupation of 3 of the communities, whereas, business was the subsidiary occupation of 2 of the communities, viz., the Harijans and the Rajputs. Both these communities were also practicing agriculture and service as their primary occupation (Table 8.15). All the communities in the three Gujjar *deras* sampled were dependent on cattle rearing activities, except for the Goudhiyas of Nemsot, who also practiced agriculture and took up labour work.

8.3.4 Dependence on the forest

While in Zones I, II and III more than 80% of the communities sampled depended on the buffer zone forest for fodder and fuelwood, dependence for timber and NTFPs was marginal (Table 8.16). However, in Zone IV, less than 50% of the communities were dependent on fodder while 75% depended for fuelwood from the buffer zone. Here also dependence for timber and NTFPs was marginal (Table 8.16). As far as the Gujjar *deras* were concerned, the three *deras* sampled were found to be totally dependent on the forest for grazing their livestock.

Leaves of six major tree species were collected by the villagers, for fodder viz., Bankali, Sanan, Sain, Harda, Kusum and Haldu. Five tree species were used for fuelwood purposes viz., Sain, Rohini, Bankali, Sanan and Eucalyptus. The local people extracted four species of grasses for domestic use, viz., Bavad, Patera, Munj and Sherva. Although none of the communities extracted NTFPs on a large scale, fruits of ten tree species were used by them for domestic consumption, viz., Bel, Semal, Amla, Imli, Aam, Jamun, Tendu, Ber, Harda and Baheda (Table 8.17).

Table 8.15: Community-wise occupational pattern of sampled households in and around buffer zone of the Corbett Tiger Reserve

Community	Major Occupation	Subsidiary Occupation
Brahmin	Agriculture and Cattle	Labour and Service
Buxa	Labour	Agriculture
Christian	Agriculture	Labour
Gadhwali	Agriculture	Service and Labour
Goudhiya	Labour	Cattle rearing and Agriculture
Gujjar	Cattle rearing	Agriculture
Harijan	Agriculture and Service	Labour and Business
Jatsikh	Agriculture	Labour
Kamboj	Agriculture	Labour and Cattle rearing
Kumarsikh	Agriculture	Service
Muslim	Agriculture	Service and Labour
Odd Rajput	Agriculture	Labour
Raisikh	Agriculture and Cattle rearing	Service and Labour
Rajput	Agriculture and Service	Cattle rearing, Service and Labour
Saini	Agriculture and Labour	Service

Table 8.16: Resource dependence pattern of sampled villages in and around buffer zone of the Corbett Tiger Reserve (percentage of communities)

Resource	Zone I	Zone II	Zone III	Zone IV
Fodder	89	100	100	38
Fuelwood	89	100	91	75
Timber	11	-	18	-
NTFPs	-	10	-	13

NTFPs: Non-timber forest products.

Note: The percentages will not add up to '100' as each community could be dependent on more than one resource.

Table 8.17: Plant products extracted by people in sampled villages in and around the buffer zone of Corbett Tiger Reserve

Fodder	Fuelwood	Grasses	Fruits
Anogeissus latifolia (Bankali)	*Terminalia tomentosa* (Sain)	*Ischoemum angustifolium* (Bavad)	*Aegle marmelos* (Bel)
Ougeinia dallbergioides (Sanan)	*Malloutus philippinensis* (Rohini)	*Typha elephantina* (Patera)	*Bombax ceiba* (Semal)
Terminalia tomentosa (Sain)	*Anogeissus latifolia* (Bankali)	*Saccharum munja* (Munj) (Sherva)	*Emblica officinalis* (Amla)
Terminalia chebula (Harda)	*Ougeinia dallbergioides* (Sanan)		*Tamarindus indica* (Imli)
Schleichera oleosa (Kusum)	*Eucalyptus* (Eucalyptus hybrid)		*Mangifera indica* (Aam)
Adina cordifolia (Haldu)			*Syzygium cumini* (Jamun)
			Diospyros tomentosa (Tendu)
			Zizyphus mauritiana (Ber)
			Terminalia chebula (Harda)
			Terminalia bellarica (Baheda)

Fuelwood-dependence and consumption pattern: Majority of the communities in the study area depended on the buffer zone for their fuelwood requirements. The major factors for dependence were 1) people could not afford alternatives; 2) improper supply of LPG (cooking gas); 3) wood was freely available. In Zone I, 'people's inability to purchase alternatives' was the cause of 100% dependence. In Zone II also, all the communities were dependent on the buffer forest for fuelwood; 70% communities attributed their dependence on the forest due to their 'inability to purchase alternative' sources of energy, 30% attributed their dependence to 'freely available fuelwood'. In Zone III, while 84% of the communities depended on the buffer zone for fuelwood because of their 'inability to purchase alternatives', 8% attributed their dependence on fuelwood to 'improper supply of LPG', while another 8% attributed it to fuelwood from forest being 'freely available'. In Zone IV, more than 60% of the communities were dependent on the forest for fuelwood due to their 'inability to purchase alternatives', while 17% attributed their dependence to 'improper supply of LPG'. The remaining 16% attributed their dependence to fuelwood being 'freely available' from the forest (Table 8.18). Although some households were found to be using alternative energy sources like biogas, fuel-efficient stoves, LPG/Kerosene and dung cakes and agricultural wastes, the dependence on these alternatives was negligible.

Table 8.18: Factors for dependence on fuelwood from the buffer zone of Corbett Tiger Reserve (percentage of communities)

Factors for dependence on CTR	***Zone I***	***Zone II***	***Zone III***	***Zone IV***
Cannot afford alternatives	100	70	84	67
Improper supply of LPG (cooking gas)	-	-	8	17
Wood from CTR was freely available	-	30	8	16

CTR = Corbett Tiger Reserve

While the daily fuelwood consumption per household in summer was highest for Zone II (12.3 kg; annual requirement per household = 4.48 tonnes), it varied between 6.33 kg to 7.5 kg for the other three zones (Table 8.19). In winter, fuelwood consumption per household was found to be almost double the amount consumed in summer, as in winter fuelwood was not only used for cooking food, but also for heating water and keeping the houses warm. In winter also, Zone II had the highest daily fuelwood consumption per household (24.2 kg), while Zone I had the lowest daily consumption per household (12.11 kg).

Table 8.19: Fuelwood consumption pattern in the sample villages in and around the buffer zone of Corbett Tiger Reserve

Zone	**Daily fuelwood consumption / household (kg)**	
	Summer	**Winter**
I	6.33	12.11
II	12.3	24.2
III	7.73	14
IV	7.5	14.19

Benefits from the buffer zone: Each community in the sample villages and *deras* was asked to identify the benefits derived and or perceived by it from the forest of buffer zone. Nine benefits were identified, viz., fuel, fodder, timber, water, NTFPs, cash earnings, cattle grazing, religious and recreational (Table 8.20). In Zone I, while all the communities considered availability of water as a benefit from buffer zone more than 50% of the communities considered fuelwood, fodder, timber, and livestock grazing as benefits. However, less than 50% of the communities in this zone derived religious and recreational benefits from the forest of buffer zone. In Zone II, while all the communities considered access to fuelwood and water as a benefit from buffer zone, more than 50% of the communities also identified access to timber, water, and livestock grazing, as well as religious and recreational benefits from buffer zone. In Zone III, all the communities identified availability of fodder as a benefit from the buffer zone. More than 50% of the communities also identified fuelwood and livestock grazing as a benefit from buffer zone. However, less than 50% of the communities in this zone considered timber, water, NTFPs as well as religious and recreational benefits that they derived from the forest of buffer zone. In Zone IV, fuelwood, fodder and livestock grazing, were identified as major benefits by 50% or more communities. Less than 50% of the communities in this zone however, derived timber, water, NTFPs, cash earnings, and religious benefits from the buffer zone. This was the only zone from which cash earning was identified as a benefit and this was primarily because of sale of fuelwood by the Buxa community (Table 8.20).

Table 8.20: Benefits to the communities in sample villages in and around the buffer zone of Corbett Tiger Reserve (percentage of communities)

Benefits / Zones	I	II	III	IV
Fuel	89	100	53	75
Fodder	89	100	100	50
Timber	67	70	33	33
Water	100	70	42	13
NTFPs	-	-	17	6
Cash Earnings	-	-	-	13
Cattle grazing	89	80	83	53
Religious	44	70	25	31
Recreation	33	60	17	-

NTFPs: Non-timber forest products.

Note: The percentages will not add up to '100' as each community derives more than one benefit.

8.3.5 Attitudes

Restriction on fuelwood: As majority of the communities were found to depend on fuelwood from the buffer zone as a major source of energy for cooking purposes, people's attitudes towards restrictions on its extraction from the forest were assessed. While only 3% of the people in the study area were willing to buy fuelwood or its alternatives, about 7% were willing to grow their own fuelwood tree species and another 17% were willing to switch to alternatives. However, majority of the respondents had negative attitudes towards restrictions on fuelwood from the buffer zone; more than 50% were willing to steal wood from the forest while 17% were willing to agitate rather than go without it (Table 8.21).

Table 8.21: Attitudes in sample villages towards restrictions on fuelwood, livestock grazing and fodder from the buffer zone of Corbett Tiger Reserve (Number of responses)

Attitudes	Fuelwood Total number of responses (%)	Livestock grazing and Fodder Total number of responses (%)
Buy	1 (3.44%)	2 (6.45)
Grow	2 (6.89)	7 (22.58)
Switch to alternative	5 (17.24)	NA
Steal	16 (55.17)	16 (51.61)
Agitate	5 (17.24)	6 (19.35)

Restrictions on fodder and livestock grazing: Although majority of the people in the study area were dependent on the forest of buffer zone either for fodder and / or grazing their livestock, only 6% of them were willing to buy fodder in case of restrictions on its use from the buffer zone. Less than 25% were willing to grow fodder on their fields. Majority of the respondents however, had negative attitudes to restrictions on fodder extraction and livestock grazing (as in the case of fuelwood extraction) - more than 50% were willing to steal fodder from the forest while 19% were willing to agitate rather than go without it (Table 8.21).

Conservation: *While all the local people in the study area felt the need for* providing protection to the forest, majority of them felt that conservation of plants and animals was beneficial for them. However, 30% of the people in Zone II felt that conservation of only plants was good for them. In Zone III, 8% of the people did not consider conservation of plants and animals as beneficial while another 8% were not sure and only 84% considered conservation of plants and animals as being beneficial for them (Table 8.22).

Table 8.22: Attitudes in sample villages towards conservation of Corbett Tiger Reserve and its buffer (percentage of responses)

Zone/ Attitude	Conservation of plants and animals is good for the people			Plants are good for the people but not animals	Corbett Tiger Reserve and it buffer needs to be protecte		
	Yes	No	Don't know		Yes	No	Don't kno
I	100	-	-	-	100	-	-
II	70	-	-	30	100	-	-
III	84	8	8	-	100	-	-
IV	100	-	-	-	100	-	-

8.4. Conclusion and discussion

The findings of the study have shown that most of the communities residing in and around the buffer zone of the CTR were depend on the forest for fuelwood, grazing of livestock, grasses and leafy fodder. This is also the case in most of the protected areas as has been discussed by several authors (Nepal & Weber 1993, Sharma & Shaw 1993), who have found that people living in and around protected areas depend on them for most of their necessities like thatch, timber, firewood, leafy fodder and supplementary grazing by livestock.

With more than 90% of the villages dependent for their livelihood needs on forest of CTR, fuelwood was major resource being extracted. This is a scenario, which is common across most of the protected areas as fuelwood forms the largest single source of supply of domestic fuel in the country (Saharia 1984). The major factor responsible for this dependence in CTR was the inability of majority of families to afford alternatives. This is the case in most of the Asian countries where a large percentage of population is poor and subsists on agriculture. Thus the large scale dependence on freely available fuelwood from the forest is the outcome of poverty because of which people in these regions are unable to purchase alternatives (Wallace 1981, Blaikie 1985). Moreover, 30% of the people extracted fuelwood from the forest, as it was freely available.

Several studies on fuelwood consumption in rural areas have also related dependence on the forests for fuelwood to various socio-economic factors like family size, settlement pattern (Negi et al. 1986, Misra et al. 1988), annual income, distance from the forest, and livestock holding (Mahendra et al. 1992). Some households in the southern villages who could even afford alternatives found themselves falling back on this source, as supply of LPG was improper. Those located in the northern portion of the buffer zone were completely depend on the forest for their fuelwood requirement as these habitations were comparatively remote and so had almost no access to alternatives. The block-wise distribution of fuelwood dependence pressure however, was high in the southern portion of the buffer zone, especially in the southeast. This could be probably due to greater dependence on a few blocks as well as the accessibility of the terrain, thus resulting higher degree of forest degradation. Restrictions on extraction of fuelwwod from the CTR however, were not acceptable to the people as majority of them were willing to steal wood from the forest and even agitate if need be rather than go without it.

Dependence on forest for livestock grazing has also received significant attention in the tropical counties as it is considered one of the major causes of degradation of forests. Increasing livestock numbers and conversion of forest to agricultural land have been considered responsible for adversely affecting the regenerative capacity of forests (Thapa & Weber 1990). Moreover, rising market prices of livestock products, unavailability of farm fodder and inadequate veterinary and extension services are also responsible for increasing livestock numbers and making pastoralism a lucrative business both for the farmers and pastoralists (Thapa & Weber 1990, Sheikh 1986). In CTR also the livestock holding pattern reflected the importance of livestock especially for the pastoral community, the *Gujjars* with the average livestock holding comparatively much higher (20.4 heads of livestock per family). This is due to the fact that for *Gujjars*, livestock is a means of livelihood.

However, out of the three *Gujjars deras* sampled in CTR, non-*Gujjars* households especially those belonging to the Brahmins had higher average livestock holding (140 heads of livestock per family) even compared to the *Gujjar* households. One factor that could also be responsible for this large livestock holding could be the status attached to livestock wealth by upper castes or it could be because of lack of off-farm opportunities and agriculture support facilities. Several studies e.g., Hudson (1980) and WRI and IIED (1987) have found that social status and economic prosperity also play a role in large livestock holdings in most tropical Asian counties.

Whatever the reason for the large size of livestock holding, these cattle, had a high degree of dependence on the buffer zone of the CTR and consequently this dependence had a negative effect on the status of the forest. Overall, more than 70% of the villages were dependent on the buffer zone of CTR for grazing their livestock. Consequently, more than 25% of the forest blocks of the buffer zone were under high livestock pressure, most of which were located in the north and northeast part of the buffer zone because of higher livestock population in this area. However, comparatively a high percentage of forest blocks of the buffer zone were under medium pressure from livestock and most of these were clustered in the northwest and southeast. Factors responsible for this dependence could be either because the habitations were located within the buffer zone, especially in north, or it could be because forest and pasture outside the buffer zone were badly degraded and therefore the dependence on the buffer zone forest increased.

Moreover, another possible factor, as suggested in several studies, could be the unavailability of farm fodder. This could also be the factor responsible for the local people in and around the buffer zone of the CTR having negative attitudes to restriction on livestock grazing and their inclination to agitate rather than having to explore alternatives.

Another related form of dependence was for grass fodder with more than 80% of the villagers in the study area dependent on the buffer zone forest. The reason and the degrees of biotic pressure as well as its spatial distribution were more or less similar to those for grazing of livestock. While about 35% of the forest block of the buffer zone were under high degree of pressure being spatially located in the eastern portion of the buffer zone. These are the areas which have higher numbers of livestock and no alternative forest/ pastures. This was reflected in their attitudes towards restrictions on fodder extraction from the buffer zone forest. More than 50% of the respondents were willing to steal fodder from the forest and agitate rather than go without it. Moreover various socio-economic factors like landlessness, marginal landholding and no regular source of income, result in people's inability to purchase alternatives. There are also probably the factors responsible for only a small percentage of the people either willing to grow fodder on their fields or to purchase it from the market.

Looking at the problem in a wider perspective, twenty one villages and 15 *deras* located within the buffer zone and another 29 villages and 2 *deras* located adjacent (within 1 km) to the buffer zone boundary had no alternative forest for either grazing their livestock or collection of fodder and fuelwood. Consequently they were completely dependent on the buffer zone of the CTR for their resource needs. In addition to these, there were 73 settlements located within a distance of 1-7 km from the buffer zone boundary. They were also dependent on the buffer zone. Moreover, out of the total households sampled more than 12% were landless and were therefore totally dependent on the buffer zone forest. The overall impact of this biotic dependence was seen in the form of a large number of forests blocks being under high anthropogenic pressure, with those in the southeastern portion being the most affected, probably because of greater dependence on a few blocks as well as other factors like terrain and lack of alternative resource-base as discussed above, thus resulting in high degree of degradation.

Apart from the dependence on forest resources, the other issues brought forth by this study were, the wildlife related problems being faced by people as well as their attitude towards conservation. Most of the PAs including intensively managed tiger reserves are facing management problems such as growing conflict between the conservation goals of the PAs and interests of the local communities in the form of increase in poaching, crop raiding by herbivores and man eating and livestock depredation by large carnivores. The problem of park-people conflicts is however, not confined to India. Relations between PAs and their immediate neighbours have always been a major problem in most developing countries (Newmark et al. 1993, Shelton 1983).

While people's dependence on the PAs has an impact on the forest and wildlife of the area, local people are also affected due to their proximity to the PA. It has been well documented that 'most aspects of the structure and functioning of Earth's ecosystems cannot be understood without accounting for the strong, often dominant influence of humanity' (Vitousek et al. 1997). Thus, it is of utmost importance to study human activities and attitudes for formulating management policies for any protected area as the people's attitudes and activities area closely linked to the problems or conflicts in the area (Head et al. 2005).

The two major wildlife related problems, that emerged in the findings of this study, viz., threat to livestock and crop depredation, are primarily the outcome of people living in close proximity to PAs on one hand and on the other the increase in wildlife populations of large carnivores over the years due to better protection provided to the forest and wildlife.

A related issue is that of people's attitude towards conservation, as it could be the direst outcome of the PA-people conflicts in an area. In CTR while the local people felt the need for providing protection to the forest, 30% of the people in Zone II (northeastern portion of the BZ) felt that conservation of only plants was good to them. Considering the fact that major cattle killing were taken place in Zone III (southeastern portion of the BZ), only 8% of the people in this zone were not in favour of conservation of plants and animals as they did not consider it beneficial to them. The majority in this zone however, considered overall conservation is beneficial to them. This could be the outcome of a lot of efforts being put into alleviating the monetary problem arising out of the high rate of cattle kills by tigers in the villages and *deras* in and around the southeastern part of the buffer zone, especially by The Corbett Foundation as well as by the forest department.

9.1 Introduction

Decline in tiger population received great deal of concern and principal threat to tiger arise from poaching or hunting of tiger and its prey, depletion of natural prey species, habitat loss and conflict with human interests. To stop decline of tiger and ensure the long-term conservation of tiger, it is neccessary to apply management practice for better management of tiger in remaining available habitats for tiger.

9.2 Management Implication in context with Corbett Tiger Reserve

The findings of study have brought forth certain management issues. Based on the study findings, personal experience and interaction with forest staff and local conservation NGOs active in vicinity of Corbett Tiger Reserve, following management measures are suggested for the better management of study area.

9.2.1 Management of chital and sambar

Density of chital and sambar, principal prey species of tiger are lower than other well protected areas. Therefore, special emphasis should be given to the management of chital and sambar, to ensure sufficient prey base available for tiger in buffer zone of the Corbett Tiger Reserve. There should be control on grazing and other anthropogenic activities of local people having negative effect on the prey abundance. Livestock compete with herbivores for resources and this reduced the reproductive success of herbivores and indirectly affects long term conservation of tiger. Moreover, proliferation of weed species also might have negative impact on habitats of ungulates and ensure low abundance of prey species.

Along with imposing restrictions on grazing whenever required, the forest department should also deliberate on providing incentives to the local people so as to win their goodwill. The people can be given permission to cut grass before fire season and during post monsoon period from areas, which may have been closed for regeneration in the buffer zone. By restricting grazing in monsoon and early winters, the forest has a better possibility for regeneration, as this is the season when new seedlings come up and grazing at this time cause a lot of damage due to trampling.

9.2.2 Reduction in human-tiger conflict

***Human casualties*:** In order to reduce conflict between tiger and local people, there is need to familiarize local people about how to avoid fatal encounter with tiger. Both forest department and other conservation NGOs should organize workshop for local people to explain them ways to minimize fatal encounter with tigers. It is always better to move in groups inside the forest during collection of fuelwood, fodder and grazing of livestock, because people in group generally safe and tiger avoid people in group. When moving in forest keeps on talking and creates other noises to announce the approach. In case of fatal encounter with tiger, never run away, maintain eye contact, stretch the body as much as possible and create loud noise. Maintain eye contact with a threatening cat and avoid bending and squat (Seidensticker & Lumpkin 1992). On encounter with tiger, turn and run, stimulate the instinct of prey and its attacks on the humans. Tigers are most aggressive on kills, with mate and cubs, therefore, people should avoid the areas having tiger kill, mating pair and tigress with cub. Before reaching a place which can provide cover to tiger, always create some noise to announce your presence.

***Livestock depredation*:** To reduce livestock depredation by tiger, people should be encouraged to adopt better livestock management practices. Majority of cases of livestock depredation occurs in absence of proper livestock guarding by local people. There should be total restriction on free ranging cattle grazing or there should be rule not to leave livestock unattended to graze in forest. People should keep dogs with grazing livestock, so that they announce the presence of tiger and livestock attendant become more alert to safeguard the livestock from attack by tiger. Findings of the study indicate that most of the time, when attendants were present with grazing livestock, they drag away tiger and save the victim. Wild prey is sufficient in buffer zone but due to availability of livestock as easy prey, tiger predate more on livestock. Tigers are quick learners (Karanth 2001). If tiger would always drag away from livestock, over the period of time, in the course of experience of failing in killing of livestock, tiger would learn that livestock is not easy prey and they switch over towards wild prey species. There should be total restriction on grazing by *Gujjars* during night as during this time tigers become most active and livestock fall prey to depredation by tigers.

Compensation schemes: To encourage tolerance of local people towards tiger conservation, paying compensation is crucial. Compensation schemes should be faster, since presently it will take 6 to 12 month to claim compensation from forest department. In addition to this, livestock owner have to complete many formalities to claim compensation. Moreover, amount of compensation is low in comparison of actual market value of livestock. Therefore, there is a need to make compensation scheme friendlier and more acceptable to local people and there should be timely revision of rate of compensation both by forest department and The Corbett Foundation.

Uplift in living standard: Despite all these measures to reduce conflict, there is need to educate and uplift the standard of living of local people. Education help in realization of importance of tiger conservation by local people and people has greater tolerance towards the conservation of tiger. Increase in standard of living, encouraged local people to switch over from livestock rearing to other alternative source of income and in turn contribute to help in reduction of human-tiger conflict. Therefore, both forest department and conservation NGOs should make joint efforts to provide standard education and source of income to local people.

9.2.3 Management of weed species

Invasion of area by weed species such as *Lantana camara*, *Parthenium* and *Cassia tora* have negative impact on habitat quality and affect abundance of prey species. There is need to eradicate weed species and stop further proliferation of weeds species. Forest department initiated eradication of lantana as an experimental exercise.

9.2.4 Maintenance of mixed vegetation

Special emphasis should be given for the maintenance of mixed habitats as they have high abundance of tiger. Moreover, monoculture plantations on southern part of area should be converted into polyculture plantations of native species and special emphasis should be given to uproot Eucalyptus plantations. Johnsingh and Negi (2003) also emphasized the conversion of monoculture plantations to polyculture plantations and suggested *Dalbergia sissoo, Holoptelia integrifolia* and *Syzygium cumini* to plant in plantations. There is dire need to regulate the utilization of grasslands by local people. Local people activity in grassland should be restricted for some period, so that grasslands recuperate.

9.2.5 Water hole management

During summer, there is acute problem of water in southern part of area. All the water sources dry up and there is no water available in Sanwalde bhabar, Dhela bhabar and North Jaspur forest blocks of the buffer area. Wild animals have to go Tumaria Dam, to drink water and fall prey to poaching. Tumaria Dam area is largely habituated by *Rai Sikkh* community, which is mostly involved in poaching of wild animals. Natural pool of water, located in North Jaspur block, get dried in summer in absence of management inputs. Therefore, forest department should maintain not only this water natural pool but also others properly to ensure the water availability to wild animals round the year.

Moreover, forest department should create artificial water holes and fill water artificially in these water holes during summer, to stop falling of prey to poaching during their passes from human settlements to drink water.

9.2.6 Management of corridors

Tiger population in buffer zone, act as sink to source population from core and source population to adjoining forest divisions. Therefore, better management of tiger population in buffer, is crucial to ensure well being of tiger population both in core and adjoining forest divisions. Corridors between buffer and adjoining forest divisions should be maintained to ensure movement of tiger and to stop inbreeding in tigers.

9.2.7 Socioeconomic implications

Socio economic study of area brings certain management and conservation implications. Firstly, employment opportunities for the 12% landless households, which are genuinely, depend on forest resources. Secondly, grazing by large number of livestock in the protected area and the resulting impact on forest vegetation as well as the conflicts arising out of it. Thirdly, the fuelwood and grass/fodder requirements of the people living within the buffer zone. And lastly, people's negative attitude towards restriction on resource use from buffer zone of the Corbett Tiger reserve.

Most of these problems require different management strategies as the protected area policy and management also has its implications for rural development of the local people. IUCNs World Conservation Strategy (IUCN 1980) has emphasized the concept of joining economic development with conservation for better management of PAs. Such a holistic approach has a better chance of achieving the objectives of conservation through positive attitude change in those who are living on close proximity to PAs, by providing them with viable alternatives and support for reducing their dependence on PAs forest

Employment for local people: The forest department along with the local NGOs and other agencies, concerned with local people's welfare, should help generate alternative sources of income through preferential employment to at least one member of the genuinely dependent families.

Reduction in bio-dependence: Management should lay emphasis on decreasing the bio-dependence of the local people though alternate non-forest based occupations like poultry farming, pisciculture etc. as well as alternative energy resources especially as this is a major resource being extracted. This can be done introducing fuel-efficient devices, smokeless stoves and biogas plants wherever there are large livestock holdings. Provision of fuel efficient devices can help in reduction of fuelwood pressure on forest as suggested by Johnsingh et al. (2004), therefore people depend on forest for fuelwood should be provided with fuel-efficient *chulas* and encouraged their use, so that the pressure on natural forest would be reduced gradually. While providing alternatives in terms of both alternative resources and source of income, the local forest-based economies must be made sustainable in the long run. The alternatives that are worked out should be readily available and viable. Moreover, women deserve special attention when providing alternatives, as they spend a major portion of their time in collecting fuelwood and water for the family as well as cooking food. Therefore, they are the ones who are not only affected more by any changes in the resource base, but can also have a greater influence and role in working out viable alternatives as well as in modifying people's attitudes towards the issues of conservation and changing the perception of people towards wildlife related conflicts. Thus the process of planning for alternatives should involve local women right from the initial stages.

Management of animal husbandry: Animal husbandry department can be persuaded to adopt a more people friendly approach and reach out to the livestock holders with essential husbandry services. At the same the livestock owners should be encouraged to adopt stall-feeding and also to maintain smaller number of more productive livestock. Furthermore, village zones can be demarcated for the purpose of grazing with local participation. This may help in restricting the effect of grazing to the areas around the villages and leaving larger areas of the forest undisturbed. Also the concept of rotational grazing can be introduced with help of local planning and participation.

Growing of fuelwood and fodder species on village land: With local participation, indigenous fast growing timber and fodder species can be introduced within village boundaries and fallow lands, so as to eventually take some pressure off the forest. While planting these trees, care should be taken to keep people's preferences for various fodder and fuelwood species. Moreover, while planting fodder species care should be taken to plant those species, that are native and which supply fodder in greater part of the year. Pasture improvement works should also be taken up, wherever possible.

People-park relationship: Relationship between parks and their immediate neighbours are of utmost importance if any conservation efforts and policies are to succeed. Allowing local people "controlled access" to certain resources of the PAs may be necessary for meeting people's critical resources needs. This may also help in building support for these protected areas (Lehmkuhl et al. 1988, Schelhas 1991). Such experiments have been successfully tried in the past in Amboseli National Park, Kenya (Shelton

1983) as well as in Chitwan National Park, Nepal (Shelton 1983, Lehmkuhl et al. 1988). The PA management can also look at the possibility of joint Protected Area Management with local communities for buffer zone of the CTR. The National Forest Policy of 1988 promotes the concept of forest management with active participation of local people. Madhya Pradesh is one of the states, which has adopted collective forest management by forming village forest protection committees (Bahuguna et al. 1994). People's participation in management of forest and its resources have already shown positive results in certain forest divisions of West Bengal and Madhya Pradesh (Malhotra et al. 1993, Dhar 1994).

9.2.8 Control of poaching

Although poaching was not quantified during study but there are evidences to suggest that poachers are active in the vicinity of Corbett Tiger Reserve and pose threat to tiger and other wild species. There should be control on poaching of wild animals. *Rai Sikkh* community, living on southern and southwestern part of the area, involve in poaching of prey species of tiger. To control poaching, forest department should set up special anti-poaching team to deal with local poachers. According to ground forest staff, we are living alone in remote areas surrounded by local people and not able to fight with whole village. If we take strict action against these *Rai Sikkh* people, there is threat of our life during night. Therefore forest department should set up anti-poaching team, to deal these people, which should located in forest headquarter and would take action on information by ground field staff.

9.2.9 Removal of encroachment

Encroachment on tiger habitats poses threat to conservation of tiger in Corbett Tiger Reserve. There is urgent need to remove encroachment and to stop further encroachment on tiger habitats. Sunderkhal, located adjoining to Corbett Tiger Reserve in Ramnagar Forest Division and Patrani, located in Terai Forest Division are two major encroachments on tiger habitat near Corbett Tiger Reserve and need immediate attempt to remove these encroachments. According to Johnsingh et al. (2004), there is dire need to remove encroachments to arrest growing threat to wild habitats and to restore corridors for wild animals.

9.2.10 Relocation of villages

Relocation of human settlements out of tiger potential habitat becomes primary focus of people involved in tiger conservation. There are 21 villages and 15 *gujjar* settlements located inside the buffer zone of the Corbett Tiger Reserve and there is urgent need to relocate them outside the buffer zone. Relocation of settlements should be conducted phase-wise. In first phase, forest department should relocate *gujjar* settlements and *khattas* as Aamdanda, Ringora, Jodisot and Nemsot, since *gujjar* settlements and *khattas* are not revenue villages and easy to relocate. During second phase, forest department should relocate revenue village located in prime habitats of tiger such as Tera, Dhela and Laldhang. Johnsingh et al. (2004) emphasized relocation of Aamdanda, Ringora and Tera villages to the Gabua forest block located in Terai West Forest Division.

9.2.11 Control on Mushrooming of hotels and resorts

Government and forest department should control the mushrooming of hotels and resorts on eastern and southern boundary of Corbett Tiger Reserve as they destroy corridors of wild animals.

9.2.12 Restriction on commercial collection fuelwood

There should be total restriction on commercial collection of fuelwood by local people. People from Ramnagar collect fuelwood from the forest to sell in market. In addition to this, *Mawawallas* also collected fuelwood for commercial purpose to make *mawas* at their *bhattis*.

9.2.13 Control on collection of *bhabar* grass

People of *Buxa* community, living on the fringe of Corbett Tiger Reserve, collect *bhabar* grass during winter. These grass cutters moves all over the area and involve in illegally fishing and stealing of fresh tiger kill whenever they found during collection of grass. There should be restriction on *bhabar* grass collection but at the same time forest department create some alternative source of income for these people as livelihood of these people depend on selling of rope prepared from *bhabar* grass.

9.2.14 Reorganization of area of Corbett Tiger Reserve

There should be need of re-organization of area of Corbett Tiger Reserve. Forest area of Ramnagar Forest Division, Terai West Forest Division and Amangarh range of Bijnore forest division should be included in Corbett Tiger Reserve as these areas has potential to hold high abundance of tiger.

9.2.15 Conservation education

Conservation of our protected areas is not possible without the support and good will of people living in and around the protected areas. Until and unless local people recognize the significance and value of their immediate surroundings and landscapes, it is not possible to get their support and good will and implementation of recommendation that involve local people would not yield desirable success (Johnsingh et al. 2004). Therefore all possible means like media, print, electronic and campaign should be utilized to realize people the importance of wildlife conservation. Involvement of local people in different activities related to wildlife conservation help in providing support of local to wildlife conservation. Students, especially undergraduates can help in spreading awareness about the importance of wildlife and forest for the well being of human kind.

9.2.16 Detailed study on tiger ecology

Tiger population in India, in spite of all conservation efforts, has declined over the last two decades and around 50% of total tiger population lives outside PAs. Habitat destruction, rise in human population, poaching, poisoning, human-tiger conflict, killing as a means of retaliation by villagers etc. are responsible for population decline of tigers. Considering the threat level the future of tiger is bleak. To ensure long term survival of tigers, it is imperative to tailor better management strategies. These management strategies should be based on sound scientific understanding of tiger ecology in different regions. In present study, it was found that livestock depredation by tiger drastically increased during monsoon. Study also indicated that livestock contributed significantly to the diet of the tigers in buffer zone. Earlier investigators supposed livestock killing is aberrant behaviour of tigers or they kill livestock under the absence of natural prey base. But our study indicated that there is sufficient prey base in the buffer zone of the Corbett Tiger Reserve. My study raise few questions which are to be dealt in future: Why the tiger kill more cattle in monsoon? If buffer zone have sufficient prey base why tiger switch their diet towards cattle? Is there any difference in ecology of tigers living in three different zones (Core and Buffer zone of CTR and Outside CTR)?

Answer to these questions is crucial to tailor the strategies for the better management of tigers and to reduce the problem of tiger human conflict in and around the buffer zone of the CTR. To find out the answer to these questions, a comparative study of tiger ecology involving radio collaring of tiger in three distinct zones as outside buffer, buffer and core zone, varying in degree of anthropogenic pressure should be conducted. Monitoring of tigers will provide information on changing ranging pattern with seasons. It will also help in to track down the factor behind drastic increase in cattle killing by tiger in the months of monsoon. Overall study will provide information on comparative ecology of tiger in different pressure zones which is helpful for forest authorities to manage tigers. Except this, the study will increase our scientific understanding of tiger ecology. The CTR is the first protected area in our country having the highest density of the tigers. This will be the first detailed ecological study in this area. There is an urgent need of having detailed knowledge of the ecology of tigers such as spacing, home range, movement pattern, habitat use and food habits of the tiger in this high density tiger zone for the continued survival of the tigers.

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*** Not seen in original**

Appendix I

Tiger Density
Blocks and area under different density categories in the buffer zone of Corbett Tiger Reserve

Years	No presence	Low density	Medium density	High density
2001- Block numbers*:	2, 7, 8, 9, 11, 15, 17, 21, 26	1, 3, 10, 14, 18, 20, 25	4, 5, 6, 12, 16, 19, 23, 24	13, 22
Total number of blocks (%) :	9 (34.6)	7 (26.9)	8 (30.7)	2 (7.6)
Area (Hectares) :	12636.3	16361.7	15522.0	2237.8
2003- Block numbers*:	2, 8, 9, 13, 15, 17, 21	1, 7	3, 4, 5, 6, 8, 10, 11, 12, 14, 16, 18, 19, 23, 24, 25	22, 26
Total number of blocks (%) :	7 (26.9)	2 (7.6)	15 (57.6)	2 (7.6)
Area (Hectares) :	8180.8	3392.6	32476.3	2708.1

* *For block number and their respective block names see Table 1.1, Chapter I.*

Appendix II

Tiger Census Data of the Forest Department**
(1999, 2001, 2003)

	1999				2001				2003			
Block Numbers*	**Males**	**Females**	**Cubs**	**Total**	**Males**	**Females**	**Cubs**	**Total**	**Males**	**Females**	**Cubs**	**Total**
1	1	1	0	2	0	1	0	1	1	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0	0
3	1	0	0	1	0	1	0	1	2	2	1	5
4	1	1	0	2	1	1	0	2	1	1	1	3
5	0	2	0	2	2	2	1	5	2	3	1	6
6	2	0	0	2	1	1	1	3	1	1	0	2
7	1	1	0	2	0	0	0	0	0	1	0	1
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	2	0	2	1	0	0	1	2	1	0	3
11	0	2	0	2	0	0	0	0	1	0	0	1
12	1	1	0	2	1	2	0	3	1	1	0	2
13	0	0	0	0	0	2	0	2	0	0	0	0
14	1	0	0	1	0	1	0	1	1	1	0	2
15	0	0	0	0	0	0	0	0	0	0	0	0
16	2	1	0	3	1	1	0	2	2	1	0	3
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	1	0	1	1	0	0	1	1	2	0	3
19	4	4	2	10	3	6	4	13	3	7	0	10
20	0	0	0	0	0	1	0	1	1	1	0	2
21	0	0	0	0	0	0	0	0	0	0	0	0
22	2	2	0	4	1	3	0	4	3	2	0	5
23	1	0	0	1	1	0	0	1	0	1	0	1
24	0	3	0	3	2	2	1	5	1	1	0	2
25	1	2	1	4	0	1	0	1	0	2	0	2
26	0	0	0	0	0	0	0	0	2	2	0	4
Total	18	23	3	44	15	25	7	47	25	30	3	58

** For block number and their respective block names see Table 1.1, Chapter I.*

*** Data pertains to the forest blocks in the buffer zone of Corbett Tiger Reserve only.*

Appendix III

Livestock Killing by Tigers
Blocks and area under different categories in the buffer zone of Corbett Tiger Reserve

Years	No conflict	Low conflict	Medium conflict	High conflict
2001- Block numbers*:	2, 3, 7, 8, 11, 13, 15, 16, 17, 18, 19, 20, 23, 26	1, 5, 6, 9, 10, 12, 14, 21, 24	-	4, 22, 25
Total number of blocks (%) :	14 (53.8)	9 (34.6)	-	3 (11.5)
Area (Hectares) :	22594.5	18286.1	-	5877.2
2002- Block numbers*:	1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 23	2, 21, 24, 26	22	4, 25
Total number of blocks (%) :	19 (73.0)	4 (15.3)	1 (3.8)	2 (7.6)
Area (Hectares) :	32869.8	8010.8	1465.3	4411.9
2003**- Block numbers*:	1, 2, 3, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23, 26	-	5, 6	4, 22, 24, 25
Total number of blocks (%) :	20 (76.9)	-	2 (7.6)	4 (15.3)
Area (Hectares):	33363.7	-	3961.7	9432.4

* *For block number and their respective block names see Table 1.1, Chapter I.*

** *Data collected during the Tiger Human Conflict Project.*

Appendix IV

Data Sheets for Prey Abundance

(A) Line Transect Monitoring Data Sheet

Project: Tiger-Human Conflict in CTR
Date: __________

Time: __________

Transect Number: _______

Team: __________________

Transect bearing: __________

Serial number	Species	Number	Sighting angle	Perpendicular distance

(B) Block Monitoring Data Sheet

Project: Tiger-Human Conflict in CTR
Date: __________

Range: __________________

Block Name / Number: __________________

Point Number: ____________________

Abundance of pellet groups:

Species	Number of pellet groups / scats / laterine sites

Appendix V

Prey Density and Biomass
Blocks and area under different density and biomass categories in the buffer zone of Corbett Tiger Reserve

Species	No presence	Low density	Medium density	High density
Chital- Block numbers*:	-	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12,13, 14, 15, 16, 17, 18, 20, 21, 23, 24, 25, 26	22	19
Total number of blocks (%) :	-	24 (92.3)	1 (3.8)	1 (3.8)
Area (Hectares) :	-	44625.2	1465.3	667.3
Sambar- Block numbers*:	2, 9,17, 25	1, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 15, 16, 18, 20, 21, 23	14, 24	19, 22, 26
Total number of blocks (%) :	4 (15.3)	17 (65.3)	2 (7.6)	3 (11.5)
Area (Hectares) :	6163.8	31011.1	6207.5	3375.4
Barking deer- Block numbers*:	2, 15	1, 3, 4, 6, 7, 9, 10, 11, 12, 13, 17, 23, 25	5, 14, 16, 21, 22	8, 18, 19, 20, 24, 26
Total number of blocks (%) :	2 (7.6)	13 (50.0)	5 (19.2)	6 (23.0)
Area (Hectares):	1822.7	23092.7	11350.2	10492.2
Wild pig- Block numbers*:	2, 15	1, 3, 5, 6, 7, 8, 10, 11, 12, 16, 17, 18, 20, 21, 25	4, 13, 14, 15, 23, 24	19, 22, 26
Total number of blocks (%) :	2 (7.6)	15 (57.6)	6 (23.0)	3 (11.5)
Area (Hectares) :	2344.8	30381.0	10656.6	3375.4
Prey biomass- Block numbers*:	-	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 23, 25	24, 26	19, 22
Total number of blocks (%):	-	22 (84.6)	2 (7.6)	2 (7.6)
Area (Hectares):	-	39827.2	4798.0	2132.6

* *For block number and their respective block names see Table 1.1, Chapter 1.*

Appendix VI

Pellet Group Density
Blocks and area under different density categories in the buffer zone of Corbett Tiger Reserve

Species	No presence	Low density	Medium density	High density
Chital- Block numbers*:	-	1, 2, 3, 8, 9, 11, 10, 12, 13, 14, 15, 16, 17, 18, 20, 21, 23, 26	4,5,6	7, 19, 22, 24, 25
Total number of blocks (%):	-	18 (69.2)	3 (11.5)	5 (19.2)
Area (Hectares) :	-	30170.8	5856.1	10730.9
Sambar- Block numbers*:	-	2, 3,4, 5, 8, 9, 10, 12, 14, 15, 19, 21, 22, 23, 25, 26	1, 6, 7, 13, 16, 17, 20, 24	11, 18
Total number of blocks (%) :	-	16 (61.5)	8 (30.7)	2 (7.6)
Area (Hectares) :	-	27808.8	16206.4	2742.6
Barking deer- Block numbers*:	-	2, 3, 4, 5, 6, 9, 10, 11, 12, 13, 14, 15, 16, 20, 21, 22, 23, 24, 25	1, 6, 17, 26	8, 18,19
Total number of blocks (%) :	-	19 (73.0)	4 (15.3)	3 (11.5)
Area (Hectares):	-	37712.9	5246.3	3798.6
Wild pig- Block numbers*:	-	2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 18, 19, 20, 21, 23, 25, 26	13,17	1, 4, 22, 24
Total number of blocks (%) :	-	20 (76.9)	2 (7.6)	4 (15.3)
Area (Hectares) :	-	36901.9	2704.0	7781.9
Nilgai- Block numbers*:	1, 2, 5, 7, 8, 9, 10, 11, 13, 15, 16, 17, 18, 19, 20, 23, 26	3, 4, 6, 14, 22, 24	12, 22	21
Total number of blocks (%):	17 (65.3)	6 (23.0)	2 (7.6)	1 (3.8)
Area (Hectares):	27916.0	14203.4	2986.5	1651.9

* *For block number and their respective block names see Table 1.1, Chapter 1.*

Appendix VII

Data Sheet for Habitat Condition and Disturbance Factors

Project: Tiger-Human Conflict in CTR
Date: __________

Range: ________________

Block Name / Number: _________________

Point Number: __________________

Habitat Condition:

1. Vegetation type: _________________
2. Vertical structure:_________________
3. %Tree cover:____________________
4. % of Shrub cover:________________
5. Total Number of trees:____________
6. % of Ground cover: _______________

Disturbance Factors:

1. Number of cut trees: _______________
2. Number of lopped trees: ____________
3. Number of cattle dung: ______________
4. % of Weed abundance: ______________
5. Total number of shrub weeds: ________________
6. Number of *L. camara*: ____________________
7. % *L. camara* cover: ______________________

Number of other shrub weeds: ____________

Appendix VIII

Importance Value Index
(Tree species in the buffer zone of Corbett Tiger Reserve)

S. N.	Local name	Scientific name	Number of individuals	Frequency	Density	Area covered (Ha)	*IVI*
1	Allanthus	Ailanthus excelsa	16	3	2.53	0.73	1.43
2	Anvala	*Emblica officinalis*	3	3	0.47	0.04	0.66
3	Arjun	*Teminalia arjuna*	1	1	0.15	0.01	0.22
4	Baheda	*Teminalia bellerica*	5	5	0.79	1.06	1.14
5	Bakali	*Anogeissus latifolia*	23	13	3.64	12.89	3.88
6	Bel	*Aegle marmelos*	24	11	3.80	3.85	3.31
7	Bhalao	*Semecarpus anacardium*	3	3	0.47	0.07	0.66
8	Bhander	*	1	1	0.15	0.01	0.22
9	Dhak	*Butea monosperma*	2	1	0.31	0.07	0.28
10	Amaltash	*Casia fistula*	22	17	3.48	2.55	4.13
11	Chilla	*Casearia tomentosa*	4	4	0.63	0.05	0.88
12	Chiroli	*	9	7	1.42	1.23	1.70
13	Dhauri	*Lagerstroemia parviflora*	44	28	6.97	10.05	7.45
14	Dum sal	*Miliusa velutina*	79	19	12.5	14.65	8.15
15	Eucalyptus	*Eucalyptus hybrid*	47	9	7.44	7.48	4.43
16	Gadvadi	*	3	3	0.47	0.07	0.66
17	Godala	*Cordia vestita*	1	1	0.15	0.02	0.22
18	Gouj	*Millettia auriculata*	4	3	0.63	0.05	0.72
19	Gular	*Ficus glomerata*	1	1	0.15	0.01	0.22
20	Haldu	*Adina cordifolia*	13	10	2.05	7.26	2.62
21	Harda	*Terminalia chebula*	2	2	0.31	0.04	0.44
22	Jamania	*	2	2	0.31	0.01	0.44
23	Jamun	*Syzygium cummini*	30	19	4.75	14.68	5.32
24	Jigan	*Lannea grandis*	17	14	2.69	4.26	3.41
25	Kachanar	*Bauhinia racemosa*	3	3	0.47	0.07	0.66
26	Kadhberi	*Zizyphus glaberrima*	13	8	2.05	0.87	2.08
27	Kadhsagon	*Haplopnragma adenophyllum*	69	12	10.96	11.43	6.32
28	Kanju	*Holoptelea integrifolia*	70	16	11.09	51.34	8.36

29 Kapoor	*Cinnamomum comphora*	1	1	0.15	0.01	0.22
30 Khair	*Acacia catechu*	19	13	3.01	3.05	3.32
31 Kharpat Jigan	*Garuga pinnata*	8	6	1.26	0.35	1.45
32 Khavad	*Ficus sps*	1	1	0.15	0.13	0.22
33 Khinna	*Sapium insigne*	4	3	0.63	0.12	0.72
34 Khuda	*Ehretia acuminata*	70	36	11.04	26.89	10.8
35 Koyali	*Bauhinia retusa*	1	1	0.15	0.028	0.22
36 Kura	*Holarrhena antidysenterica*	4	2	0.63	0.22	0.56
37 Kusum	*Schleichera oleosa*	26	16	4.11	14.51	4.60
38 Lasoda	*Cordia dichotoma*	8	6	1.26	0.75	1.46
39 Madara	*Syzyzium cerasioudes*	4	4	0.63	0.09	0.88
40 Mahua	*Madhuca indica*	1	1	0.15	0.01	0.22
41 Maida	*Litsea lanuginose*	2	1	0.31	0.07	0.28
42 Makuli	*	1	1	0.15	0.01	0.22
43 Marchhia	*Murrya paniculata*	11	4	1.74	0.43	1.30
44 Muraya	*Murrya koenigii*	3	3	0.47	0.01	0.66
45 Pilkhan	*Ficus rumphii*	1	1	0.15	0.26	0.22
46 Pola	*Kydia calycina*	2	1	0.31	0.01	0.27
47 Rohini	*Mallotus philippinensis*	458	118	72.56	728.91	70.01
48 Sadan	*Ougeinia dalbergioides*	24	16	3.80	3.79	4.12
49 Safad Siras	*Albizzia procera*	1	1	0.15	0.01	0.22
50 Sal	*Shorea robusta*	346	79	54.82	1961.28	98.17
51 Sain	*Terminalia tomentosa*	20	12	3.16	7.99	3.38
52 Sissam	*Dalbergia sissoo*	7	5	1.10	0.41	1.23
53 Teak	*Tectona grandis*	125	15	19.8	64.87	11.83
54 Tendu	*Diospyros exsculpta*	60	35	9.5	32.77	10.27
55 Unidentified	*	1	2	0.15	0.01	0.38
56 Vad	*Ficus benghalense*	9	8	1.42	12.96	2.25
57 Ber	*Zizyphus mauritiana*	1	1	0.15	0.01	0.22

** Scientific names could not be identified.*

Appendix IX

Disturbance Factors

Blocks and area under different disturbance categories in the buffer zone of Corbett Tiger Reserve

Disturbance factors	No pressure	Low pressure	Medium pressure	High pressure
Cutting pressure- Block numbers*:	-	1, 3, 6, 7, 9, 12, 13, 14, 16, 18, 19, 23, 24, 25	2, 4, 5, 11, 17, 26	8, 10, 15, 20, 21, 22
Total number of blocks (%):	-	14 (53.8)	6 (23.0)	6 (23.0)
Area (Hectares) :	-	25703.9	9585.9	11468.0
Lopping pressure-	19	1, 3, 5, 6, 7, 9, 11, 13, 18, 23, 24, 25	2, 4, 12, 14, 16, 20, 21	8, 10, 15, 17, 22, 26
Total number of blocks (%):	1 (3.8)	12 (46.1)	7 (26.9)	6 (23.0)
Area (Hectares) :	667.3	22047.6	13578.1	10464.8
Dungpiles / grazing pressure- Block numbers*:	19	1, 3, 5, 6, 7, 8, 9, 11, 14, 15, 16, 18, 20, 23, 24	2, 4, 13, 17, 21, 25	10, 12, 22, 26
Total number of blocks (%) :	1 (3.8)	15 (57.6)	6 (23.0)	4 (15.3)
Area (Hectares):	667.3	28869.6	9698.7	7522.2
Lantana camara- Block numbers*:	-	1, 2, 3, 5, 6, 7, 9, 10, 11, 13, 14, 16, 17, 18, 20,	6, 8, 12, 23, 24	4, 15, 19, 25, 26
Total number of blocks (%) :	-	16 (61.5)	5 (19.2)	5 (19.2)
Area (Hectares) :	-	30946.1	9227.9	6583.8
Overall Biotic pressure-	-	1, 3, 6, 7, 9, 18, 19, 23, 24	2, 4, 5, 11, 12, 13, 14, 16, 20, 25	8, 10, 15, 17, 21, 22, 26
Total number of blocks (%):	-	9 (34.6)	10 (38.4)	7 (26.9)
Area (Hectares):	-	15838.6	18802.5	12116.7

* *For block number and their respective block names see Table 1.1, Chapter I.*

Appendix X

Project: Tiger-Human Conflict in CTR
Date:__________

Village Reconnaissance Data Sheet

1. Village name________________________
2. GPS location:_________
3. Village type: Forest / Revenue
4. Distance from core (NP) boundary:___________
5. Distance from sanctuary:______________
6. Area of the village:______________
7. Range:_______________
8. Compartment / Block:________________
9. Beat:________________
10. Any water body outside / within the village:_____
11. Status of forest around village: Poor / Average / Good
12. Caste communities:______
13. Human population:_________
14. Number of households:________
15. Livestock population:______
16. Where do the cattle go for grazing: Compartment / Beat / Distance.
17. Agricultural area:__________
18. Crops grown:
    (i) Winter
    (ii) Summer
19. Major occupations:________________
20. Resource dependence on forest:
    (i) Fuelwood
    (ii) Timber
    (iii) Grasses
    (iv) NTFP - food
    (v) NTFP - medicine
21. Major wildlife related problems identified by villagers:
    (i) Crop depredation by elephants / chital / sambar / wild pig / nilgai
    (ii) Threats to humans by elephants / tigers / leopards
    (iii) Absence of village pastures
    (iv) Any other problem
22. Basic facilities available in the villages:
    (i) Health
    (ii) Education
    (iii) Transport
    (iv) Markets

Appendix XI

Project: Tiger-Human Conflict in CTR
Date:_________

Community Based Socio-economic and Dependence Survey

1. Zone:_________
2. Village:__________________
3. Community:_____________
4. Human population:_______ Males:_______ Females:______
   Children(<15):________
5. Number of households :_____________
6. Average household size:_________
7. Major occupation of the community:____________
8. Subsidiary occupation of the family:_____________
9. Average landholding / household:_______________
10. Landless households:______________
11. Average cattle holding / household:_____________
12. Total livestock holding of the community:
    (i) Buffaloes:________ Ox: __________Calves:____________
    (ii) Cows: _______ Bulls: ____________ Calves:___________
    (iii) Goats: _________
    (iv) Sheep: ________
    (v) Horses: ________
    (vi) Mules: _________
13. Is the cattle stall-fed / free ranging?
14. If free ranging forest used for grazing cattle:_____________
15. Products collected from the forest annually by the community:

Product	Season	Sold	Consumed

16. Average fuelwood consumption / household:
    (i) Summers: _____________Kg / day
    (ii) Winters: _________________Kg / day
17. Where do the people collect the following from:
    (i) Wood-Fuel / timber: CTR / adjacent forest
    (ii) Fodder-leaves / grasses: CTR / adjacent forest
    (iii) NTFPs (others) CTR/adjacent forest

Appendix XII

Project: Tiger-Human Conflict in CTR
Date: ________

Attitudes Survey – I: Community Attitudes towards Fuelwood / Fodder and Alternatives

Zone: _______________

Village: _____________

Community : ______________

Fuelwood / Fodder :

Reason for using fuelwood from the CTR forest :

a) Can't afford anything else
b) Improper supply of LPG / kerosene
c) Wood is available free of cost

Have any of following alternative fuels been adopted:

Alternative	Number of households
a) Biogas	_______
b) Fuel efficient stoves	_______
c) LPG / Kerosene	_______
d) Dung Cakes / Agricultural waste	_______

If there were restrictions on collecting fuelwood from the forest, what would you do?

a) buy wood from market
b) steal from the forest
c) agitate
d) grow fuel wood on village land
e) switch to alternative fuel

Do you grow fodder in your field: Yes / No

If "No", reason:

a) Lack of land
b) Lack of water
c) Lack of labour
d) Do not feel the need to grow fodder

Alternatives :

1. Would you accept the following alternatives to forest fodder (Yes / No)

a) Purchase fodder
b) Grow fodder
c) Cut & take away fodder, instead of grazing the livestock in the forest

2. Will you exchange your livestock for fewer but more productive livestock (Yes / No).

If "No" reason:

a) Shortage of fodder
b). Shortage of manpower

c). Any others

3. Would you be willing to purchase fuelwood at nominal fee from the forest (Yes /No).

Appendix XIII

Project: Tiger-Human Conflict in CTR
Date: __________

Attitudes Survey – II: Community Attitudes towards CTR

1. Zone: ________________
2. Village : ________________
3. Community : ____________
4. What benefits you derive from the forest?
    a. Fuel
    b. Fodder (leaves/grasses)
    c. Timber
    d. Water
    e. Other NTFPs
    f. Cash earnings
    g. Cattle grazing
    h. Religious
    i. Recreation
5. Is conservation of plants & animals good for you?

    Yes / No / Do not know

6. Is there a need to protect to the forest?

Yes	No
i) It is important to conserve the forest for future generations	i) The animals cause problems for us ii)There is no benefit from protecting animals iii) We are no permitted by forest staff to -to take our cattle for grazing in CTR -collect fodder / timber / fuelwood

Appendix XIV

Details of villages surveyed in and around the buffer zone of CTR

S. N.	Village	GPS Location	Distance to CTR (km)	Number of Households	Human population	Cattle population	Community
1	Aamdanda khattta	29 25 13 79 07 17	Inside	108	573	225	Hindu
2	Aamdanda palla	29 42 54 78 49 18	1	20	150	250	Hindu
3	Aamdanda valla	29 42 58 78 49 04	1	15	159	260	Hindu
4	Acchron	29 35 32 79 07 49	2	106	750	865	Hindu
5	Amlesha	29 47 48 78 42 02	1	44	400	60	Hindu
6	Bageda	29 43 23 78 49 27	2	67	783	2000	Hindu
7	Bakhrauti	29 37 05 79 02 49	Adjacent	50	713	1200	Hindu
8	Balyuli	29 35 45 79 05 02	Inside	14	150	100	Hindu
9	Baniyawala	29 37 30 79 46 12	3	115	1500	1500	Hindu, Sikh
10	Banjadevi	29 39 21 78 53 30	Inside	15	80	75	Hindu
11	Barai	29 43 23 78 50 58	2	62	300	800	Hindu
12	Baseri	29 36 38 79 62 12	Adjacent	14	90	115	Hindu
13	Bawani	29 38 28 78 59 12	0.5	47	242	242	Hindu
14	Bhagatpur Mandiyal	29 21 47 79 03 23	5	50	300	300	Sikh, Hindu, Muslim
15	Bhagatpur Tadiyal	29 21 40 79 03 11	5	25	200	200	Sikh,Hindu
16	Bhikkawala	29 28 34 78 46 00	Adjacent	175	1700	750	Hindu, Sikh
17	Bhogpur	29 29 57 78 40 13	3	517	4400	2241	Buxa, Sikh
18	Biltiya	29 45 14 78 44 44	2	65	400	109	Hindu
19	Chandpur	29 42 11 78 51 05	3	12	60	100	Hindu

20	Chaprat	29 43 40 78 47 57	1	34	300	150	Hindu
21	Chhajmalwala	29 26 53 78 50 40	1.5	200	1500	700	Hindu, Sikh,
22	Chilon	29 39 26 78 58 00	1	58	347	454	Hindu
23	Chorpani	29 23 29 79 06 20	Adjacent	200	1100	170	Hindu, Muslim, Christian
24	Chukam	29 32 10 79 06 42	3	72	476	130	Hindu
25	Dabru	29 42 42 78 47 30	Inside	29	238	280	Hindu
26	Devi chaur (FE)	29 29 44 79 08 09	Adjacent	25	60	60	Hindu
27	Devipur Basitila	29 22 44 79 03 36	3	156	750	1000	Hindu
28	Devri	29 47 45 78 42 42	1	33	150	60	Hindu
29	Dhamdar	29 41 28 78 51 20	1	40	410	400	Hindu
30	Dhannas	29 36 02 79 07 38	4	34	175	96	Hindu
31	Dhaura	29 42 33 78 49 39	1	10	120	150	Hindu
32	Dhawra palla	29 47 07 78 42 30	2	36	275	300	Hindu
33	Dhawra walla	29 47 12 78 42 41	2	24	90	200	Hindu
34	Dhela	29 24 56 78 59 54	Inside	210	1600	1700	Hindu, Sikh, Muslim
35	Dhikuli	29 27 53 79 08 49	Adjacent	192	1061	300	Hindu, Muslim
36	Dhikulia	29 40 00 78 52 08	1	82	545	150	Hindu
37	Diodh(Veerubadi)	29 39 05 78 59 52	Inside	22	154	115	Hindu
38	Dobaria	29 42 10 78 50 47	1	30	209	225	Hindu
39	Fatehpur Dhara	29 26 54 78 50 40	1.5	310	1800	700	Hindu, Sikh,
40	Gajarijal	29 39 58 78 51 53	1	15	88	100	Hindu
41	Gajwad	29 46 41 78 39 40	2	50	500	470	Hindu
42	Garjia	29 28 42 79 08 57	Adjacent	73	382	200	Hindu, Muslim
43	Ghirauli	29 36 05 79 03 02	1	2	22	50	Hindu
44	Goujani	29 23 33 79 06 03	Adjacent	250	1300	418	Hindu Muslim, Christian
45	Gunetha	29 47 18 78 40 25	1.5	11	70	100	Hindu
46	Gwala malla	29 37 31 79 03 26	1	30	250	600	Hindu

47	Himmatpur Dodiyal	29 23 53 79 04 46	Adjacent	65	400	325	Hindu, Muslim
48	Jameria	29 35 26 79 05 03	Inside	45	600	200	Hindu
49	Jamur	29 35 33 79 03 22	Inside	2	6	66	Hindu
50	Jaspur	29 25 15 78 49 03	5	15	75	60	Hindu, Sikh,
51	Jhargaon	29 37 07 79 07 09	3	104	1000	500	Hindu
52	Jhart	29 40 11 78 51 36	1	100	400	200	Hindu
53	Jhudangu	29 37 02 79 00 33	Adjacent	40	200	300	Hindu
54	Jhullukhatta	29 23 21 78 53 49	Adjacent	40	600	700	Hindu, Muslim
55	Jhundai	29 42 25 78 51 46	2	30	160	205	Hindu
56	Jui	29 39 57 78 54 27	3	25	128	121	Hindu
57	Jukanya	29 43 23 78 50 58	3	40	190	300	Hindu
58	Kalilango	29 39 07 78 57 21	1	21	185	310	Hindu
59	Kalinko	29 39 27 78 52 58	1	20	96	60	Hindu
60	Kalluwala	29 26 24 78 48 24	5	270	2465	1500	Hindu, Sikh, Muslim, Christian
61	Kandnala	29 38 27 78 55 33	Inside	85	1000	125	Hindu
62	Kaniya	29 23 29 79 04 54	Adjacent	275	2500	390	Hindu, Muslim, Sikh, Christian
63	Karanpur	29 22 51 79 05 14	2	50	460	175	Hindu
64	Kartiya	29 39 58 78 52 57	Inside	190	900	800	Hindu
65	Khadrashi	29 38 23 78 56 57	Inside	80	525	2500	Hindu
66	Khubani	29 43 47 78 47 03	1	150	600	900	Hindu
67	Kiratpur	29 25 04 78 49 35	3	150	750	800	Hindu, Sikh,
68	Kuankhera	29 30 08 78 40 54	Adjacent	400	5000	5000	Sikh, Buxa, Hindu
69	Kumaldi	29 40 39 78 51 03	1	96	551	250	Hindu, Nepali
70	Kunpi	29 37 12 79 06 14	2	37	267	310	Hindu
71	Kvarali	29 42 01 78 49 42	Adjacent	9	62	200	Hindu
72	Lacchampur Their	29 23 09 79 04 09	2.5	86	435	700	Hindu

73	Ladua	29 27 17 79 08 38	Adjacent	39	127	43	Hindu, Muslim
74	Lalbagh Kalluwala	29 27 25 78 49 31	Adjacent	40	305	250	Sikh
75	Laldhang	29 26 03 78 57 32	Inside	55	240	260	Hindu
76	Lalpur Basitila	29 22 29 79 03 20	5	50	300	350	Hindu
77	Liuthiya	29 36 32 78 58 18	Adjacent	80	360	200	Hindu
78	Majhola	29 47 54 78 40 23	1.5	16	65	100	Hindu
79	Maloni	29 27 38 78 48 29	Adjacent	35	220	210	Hindu, Sikh
80	Manorathpur Basitila	29 21 59 79 03 03	5	25	100	125	Hindu
81	Meruda	29 44 55 78 46 32	2	65	350	800	Hindu
82	Mirapur(N)	29 27 11 78 47 37	Adjacent	110	900	550	Hindu, Sikh
83	Mirapur(S)	29 27 16 78 46 37	Adjacent	125	1000	400	Hindu, Sikh
84	Mohan	29 32 34 79 06 24	2	35	346	90	Hindu
85	Nagtale	29 36 35 79 07 01	3.5	30	300	175	Hindu
86	Nagyana	29 46 07 78 44 23	1	84	253	450	Hindu
87	Nai Basti Dhara	29 26 57 78 50 26	2	75	400	350	Hindu, Sikh
88	Narayanwala	29 25 33 78 47 24	7	501	4400	3000	Hindu, Sikh, Muslim
89	Narsinghpur	29 21 53 79 04 04	5	100	600	600	Sikh,Hindu
90	Naudanu	29 39 34 78 53 25	Inside	50	500	605	Hindu
91	Old Kalagadh	29 29 20 78 45 41	Adjacent	750	4000	500	Hindu, Sikh, Muslim
92	Pand	29 36 32 78 58 11	Inside	25	100	150	Hindu
93	Papri (Padyarpani)	29 40 19 78 53 52	3	44	331	225	Hindu
94	Raibhanwala	29 24 56 78 48 24	5	15	80	40	Hindu, Sikh,
95	Raisera	29 44 52 78 44 15	Inside	15	86	63	Hindu
96	Ramisera	29 44 06 78 44 30	Inside	9	75	70	Hindu
97	Ramjiwala	29 34 13 78 35 01	3	162	2000	480	Muslim, Sikh
98	Raninagal	29 25 45 78 50 30	Adjacent	70	350	300	Hindu, Sikh, Muslim

99 Rathuadhab	29 40 16 78 51 00	Adjacent	15	144	89	Hindu
100Ringora khatta	29 26 08 79 07 37	Inside	38	236	138	Hindu
101Roudari Badi	29 39 22 78 56 25	Adjacent	12	113	91	Hindu
102Roudari Choti	29 39 36 78 56 04	Adjacent	28	166	217	Hindu
103Saraud	29 37 03 79 05 45	1.5	22	125	155	Hindu
104Sawakdeh(E)	29 24 08 79 03 45	Adjacent	85	700	380	Hindu, Muslim
105Sawaldeh(W)	29 24 16 79 03 11	Adjacent	310	1800	700	Hindu, Muslim, Buxa
106Semalkhalia	29 23 50 79 04 11	Adjacent	250	1000	1000	Hindu, Muslim, Sikh, Christian
107Semalkhet	29 41 34 78 51 24	Inside	16	133	160	Hindu
108Shankar	29 35 59 79 05 41	Inside	25	300	200	Hindu
109Sheruvadi	29 47 13 78 41 21	1	6	45	50	Hindu
110Sidhpur	29 45 17 78 44 38	1.5	16	150	37	Hindu
111Silwad	29 45 05 78 45 15	1	70	400	350	Hindu
112Simalsera	29 44 58 78 44 23	1	32	185	305	Hindu
113Sindhikhal	29 47 38 78 40 04	1	40	345	410	Hindu
114Sunderkhal(FE)	29 30 16 79 07 20	Adjacent	300	2500	1000	Hindu
115Tediya	29 37 28 78 56 28	Inside	72	350	600	Hindu
116Thalla	29 38 49 79 07 27	2.5	150	1000	535	Hindu
117Timalsain	. 29 43 33 78 49 38	2	64	500	60	Hindu
118Ummedpur	29 22 37 79 04 25	2	35	350	250	Hindu, Sikh
119Upgaon Malla	29 39 20 78 56 45	1.5	22	185	195	Hindu
120Upgaon Talla	29 39 07 78 57 21	1	31	203	400	Hindu
121Vadhgadh	29 36 09 79 04 27	Inside	1	6	10	Hindu
122Vadrana	29 36 13 79 06 21	0.2	30	310	180	Hindu
123Virbhanwalla	29 31 52 78 38 58	4	300	1500	200	Sikh

Appendix XV

Details of Gujjar deras in and around the buffer zone of CTR

S. N.	Gujjar Settlement	GPS location	Distance to CTR	Number of Households	Human population	Cattle population	Community
1	Bodali sot	29 43 23 78 45 48	Inside	1	14	40	Muslim
2	Dhaulkhand	29 34 42 78 37 35	Inside	26	74	164	Muslim
3	Goujada	29 37 08 78 50 22	Inside	8	60	422	Muslim
4	Jhullukhatta	29 25 24 78 51 15	Adjacent	15	150	350	Muslim
5	Sawalde Plot no. 17	29 22 39 79 01 14	Inside	15	51	474	Muslim
6	Sawalde Plot no. 3	29 21 34 79 01 23	Inside	9	38	200	Muslim
7	Murgabhoj	29 24 21 78 55 04	Inside	1	4	20	Muslim
8	Pattharkuan	29 24 20 78 55 42	Inside	8	49	148	Muslim
9	Hathiya sot	29 30 20 78 43 52	Inside	2	20	40	Muslim
10	Judi sot	29 30 02 78 43 06	Inside	5	32	150	Muslim
11	Kalushahid	29 33 52 78 39 54	Inside	8	52	120	Muslim
12	Khansur	29 42 58 78 43 40	Inside	13	42	110	Muslim
13	Mudiapani	29 41 45 78 46 29	Inside	1	10	25	Muslim
14	Nemsot	29 31 21 78 41 40	Inside	12	100	140	Muslim, Hindu
15	Pakhro	29 36 15 78 36 46	Inside	3	20	31	Muslim
16	Phanto	29 22 57 78 55 53	Adjacent	5	50	250	Muslim, Hindu
17	Vatanvasa	29 42 02 78 45 11	Inside	4	26	85	Muslim

Appendix XVI

Biotic Dependence
Blocks and area under different dependence categories in the buffer zone of Corbett Tiger Reserve

Biotic factors	No dependence	Low dependence	Medium dependence	High dependence
Human population- Block numbers*:	7,19	2, 3, 6, 9, 11, 13, 14, 16, 18, 20, 22, 23	1, 4, 8, 10, 17	5, 12, 15, 21, 24, 25, 26
Total number of blocks (%) :	2 (7.6)	12 (46.1)	5 (19.2)	7 (26.9)
Area (Hectares) :	3192.9	21483.7	10256.3	11824.9
Livestock population- Block numbers*:	7, 19	1, 3, 4, 5, 6, 9, 11, 16, 18, 23	1, 2, 4, 10, 17, 22, 24, 25	8, 12, 13, 15, 20, 21, 26
Total number of blocks (%) :	2 (7.6)	9 (34.6)	8 (30.7)	7 (26.9)
Area (Hectares) :	3192.9	17916.1	17506.9	8141.9
Fuelwood: Block numbers*:	19	7, 9, 13, 16, 18, 20	1, 2, 3, 6, 8, 10, 11, 14, 15, 17, 23	1, 2, 4, 5, 21, 22, 24, 25, 26
Total number of blocks (%) :	1 (3.8)	6 (23.0)	11 (42.3)	8 (30.7)
Area (Hectares):	667.3	10714.6	20453.1	14922.8
Fodder- Block numbers*:	-	3, 6, 7, 9, 12, 13, 14, 16, 18, 19, 21, 23,	4, 8, 11, 20, 22	1, 2, 5, 10, 15,17, 24, 25, 26
Total number of blocks (%) :	-	12 (46.1)	5 (19.2)	9 (34.6)
Area (Hectares) :	-	20416.1	8563.2	17778.5

* *For block number and their respective block names see Table 1.1, Chapter I.*